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Sun Sieving: Automated Solar-Powered Extraction of *Solanum Lycopersicum* (Tomato) Seed, Pulp, and Juice Using Arduino Microcontroller

Alan P. Nebrida^{1*}, Mae Joy U. Pilde¹, Lealyn V. Madayag², Renato Allen S. Bungabung², Klemens Von A. Almeniana², John John B. Billo Jr.², Joan M. Nebrida²

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ABSTRACT

This paper presents a novel method by developing the Sun Sieving system, which integrates solar energy with automated control technology to enhance the extraction of components from *Solanum Lycopersicum* (tomato). The system addresses two significant challenges in agriculture: enhancing the efficiency of factory farming and promoting sustainable practices. This research aims to implement automation and renewable energy technologies to replace energy-intensive, labor-heavy methods while ensuring high quality in tomato processing. It employed a developmental design focusing on the development and manufacturing part of Sun Sieving, an Arduino Uno-based solar powered extraction machine. Using a microcontroller allows for everything from pH monitoring to UV sterilization in order keep the juice extracted from disease or pest free. This design allows seeds, pulp and juice to be separated efficiently while waste is kept to a minimum. The automated functionality of the system was validated over many experiments, in which UV light sensor was turned off whenever at least there is no power and turn-on upon detection that leads to elongated shelf life. The system maintained a consistent pH range of 4.0 to 4.5, thereby optimizing flavor profile and ensuring food safety standards. This step, including seed removal and processing of the pulp yielded a consistent volume of 1.3L each time. Sun Sieving has a highly effective system which confirms juice quality and has been developed as micro-scale devices. It shows that the implementation of new technologies and solar energy can greatly improve product quality. This system focuses on automation and sustainable solutions and tackles existing problems in food processing, delivering profound insights, innovation and evolution in the field.

INTRODUCTION

High efficiency and sustainability are increasingly significant in modern agriculture, and tomato agriculture is a good example of where to be applied. Despite its importance as a basic component in the diet, the tomato field appears to confront several difficulties. For example, the large volume of tomato that goes to waste, the time-consuming and labor-intensive preparation procedure, and the reliance on high-priced and ecologically damaging nonrenewable energy sources including fossil fuel. This is especially prevalent in an area such as Nueva Vizcaya in Ilocos Norte, as farmers are largely compelled to throw away excessive food because of market conditions and the high costs of delivering the food to the necessary destination. Thus, the backdrop of this research is precisely linked to approaching environmental and economic issues in tomato cultivation using original perspectives.

Improvement in agricultural technology has undoubtedly resulted in progress in processes that may increase the pace of agricultural output and make it more sustainable. This study has largely targeted mechanical and chemical strategies to make the most of agriculture products processing, notably tomato processing. The use of renewable energy sources has been one of the main

fields of study owing to the aim of reducing reliance on traditional nonrenewable energy sources and decreasing impact on the environment. Nonetheless, research is commonly focused on various techniques; therefore, the whole method might be disjointed. Moreover, research has generally not been focused on tomato processing. Moreover, research appears to be missing when combining to create an integrated system that is efficient and practical for various jobs such as tomato juice and pulp extraction of tomato seeds.

The specific requirements faced in the tomato processing sector emphasize the gaps in the current level of research and technical development. There are no solutions combining efficient processing, sustainable energy use, and practical application, primarily for small and medium farms. Although renewable energy sources have developed significantly, the level of equipment in agricultural processing, including that with perishable tomatoes, has not caught up. Moreover, there is a shortage of technology for processing and making it safe and safe quality-wise, meaning starting from effective extraction to the monitoring of it with the final product's microbiological safety and acidity. The Sun Sieving project aims to offer a solution by proposing the solar-based system's creation that can process tomatoes efficiently

¹ Electrical Engineering Department, Nueva Vizcaya State University, Bambang Campus, Bambang, Nueva Vizcaya, 3702 Philippines

² College of Industrial Technology, Hospitality, Restaurant and Tourism Management, Nueva Vizcaya State University, Bambang, Nueva Vizcaya, 3702 Philippines

* Corresponding author's e-mail: ap_nebrida@nvsu.edu.ph

and use new technology such as the Arduino Uno for more effective quality control. Such coverage is not present in the current solutions and is the most obvious direction where agricultural technology innovation can advance. The object of the study is the Sun Sieving – a ground-breaking solar-powered extractor for tomato pulp, juice, and seeds.

The immediate issue of concern being addressed by the project is the urgent response associated with the problems of tomato farming, such as the overproduction of tomatoes, commercially expensive and labor-intensive tomato processing, and a lack of renewable electric power solutions. The use of solar energy is projected to lead to a significant environmental impact as well as cutting-edge methods. The facts of the development of such a solution as the Arduino Uno microcontroller also being driven for quality and security adjustable to the standard of the ingredients expected to be extracted. The change in tomato processing will be a turning point as renewable power sources such as solar converge with technological innovation to forge a much more economic, environmentally benign and sustainable sector. Hence, the subject is intended to solve or provide a solution to the problem.

The study is relevant to many stakeholders and large industries. Sun Sieving is offered as a simple, efficient, and time-saving technology for tomato processing that may help save labor and increase productivity for growers. The method is practical because it provides a useful mechanism of dealing with the surplus fruit, given that the losses are largely caused by the tomatoes overflow. Seed production for tomatoes will benefit from the use of the automated extraction method in terms of productivity, efficiency, and reduced labor costs. This study can also be a valuable guide for future experiments related to agricultural processing technology. Economically, Sun Sieving could boost tomato farmer revenues with software's capacity to reduce waste and sustainable development. Local government agencies may use Sun Sieving to improve their agricultural systems, obtaining efficiency and economic development through resource use and waste reduction. Food processing entrepreneurs may be fascinated by the sun Sieving because it optimizes production processes and creates fresh business areas on waste products like tomato pulp fortification and about 300 other tomato seed varieties.

It is important to note that the Sun Sieving machine study scope and limitation revolve around design, development, and testing. These are factors, including the correct choice of materials, design optimization to increase efficiency based on design parameters, and effective use of solar power for tomato processing. Furthermore, the investigation involves programming and operating the Sun Sieving and Arduino Uno to control quality, focusing on acidity monitoring, among others to utilize filtered UV light for sterilization of the system. The study limitations include the exclusion of the Sun Sieving commercial output and comprehensive economic explanation. This

research only covered how to build a solar powered extractor technically and failed to consider, among other factors, nutritional analysis, duration and lifespan of extracted product storage, and a full environmental and social account of what may entail the use of this system in the food processing industry. Therefore, the research thrust is still focused on the solar powered tomato processing machine's technical viability and efficiency.

MATERIALS AND METHODS

Conceptual Framework

Figure 1 The conceptual framework of the “Sun Sieving” project is expansive and encompasses all the related research topics. From the challenges faced during the cultivation of tomatoes to the creation of solar-powered extraction technology and the potential effects, the framework covers a comprehensive area. The current issues in tomato cultivation are highlighted from the input stage. The key output is the waste due to overproduction; the extraction process itself requiring extensive labor, and the need for and reliance on nonrenewable energy sources.

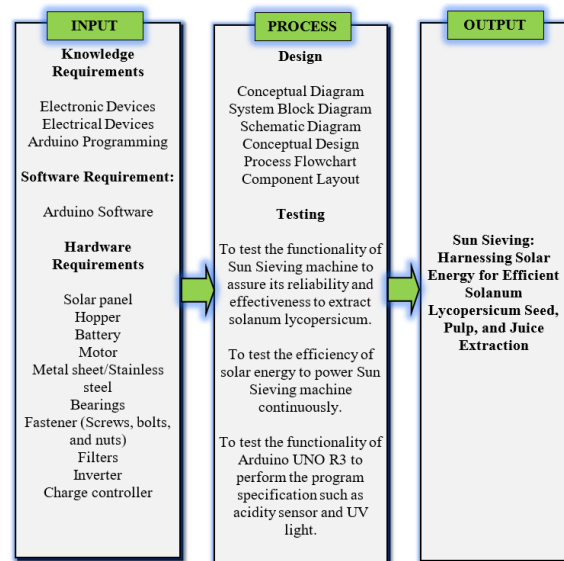


Figure 1: Conceptual Framework

The input of this system indicates that a solution is required, and that solution will need technical progress and sustainability; hence, a feasible and sustainable solution is necessary. The next stage of this framework is the processing stage that includes all the parts of the Sun Sieving project completion. This includes the design and creation of a solar-powered extractor, material issues, and performance parameters, such as design optimization and the use of solar panels and electrical controllers, in this case, Arduino Uno. In addition, the program and integration stage should be designed and focused on the development of software that will enhance efficiency and monitoring in this area, mostly focusing on the UV

sterilization sensors and acidity sensors. All the output systems should be tested and help in evaluating the applicability of the Sun Sieving output. Several outcomes would emerge from the described conceptual framework. First, the Sun Sieving extractor is developed as a tangible product that incorporates the economy, efficiency, and environmental friendliness. Additionally, the use of the latest extraction technology can improve tomato product quality and safety.

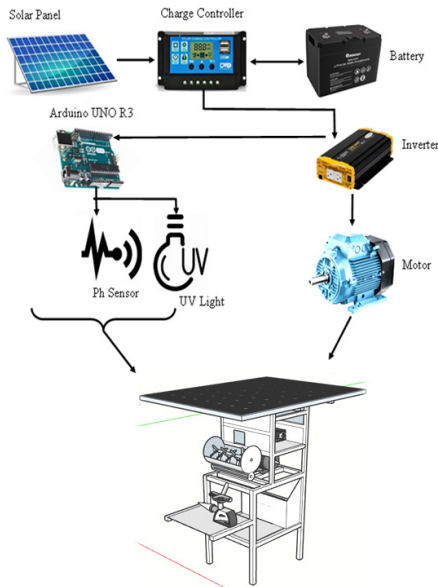


Figure 2: Conceptual Diagram

Conceptual Design

The conceptual design for the Sun Sieving machine as shown in Figure 2 begins from the solar panel which harvests the direct current (DC) electricity when it is illuminated. This energy is used to power the system, and the size of the solar panel is calculated according to required power of system. It is equipped with a charge controller that prevents overcharging, makes sure you are getting the best possible life out of your battery by controlling its charge from the solar panel. The solar panel can generate energy, it will be stored in a battery and when there is no sunlight, the system will take the power from this battery. Both the direct current battery also generates is converted in inverter to an alternating current (AC) that feeds your motor and other components of system. In addition, a computerized system has been used to assess the UV light and acidity of the tomato fluid. Controlled with a potentiometer, the UV light provides that too much light won't endanger the liquid's cleanliness. The voltage from the solar panel as well as battery is not fixed therefore to keep fixed output of both devices, A voltage regulator is included in circuit, which gives constant voltage supply for microcontroller during operation. A pH acidity sensor is used to measure the pH level of fluid, and the microcontroller can receive that information and adjust system functionality based on those readings. The liquid is disinfected using Ultraviolet

light and microcontroller controls the intensity of UV light based on the acidity of the fluid.

It uses an extractor to specifically extract tomatoes, separating the puree and liquid from the seeds. This extracted juice is then collected, along with the sediment and seeds and placed in separate containers.

Schematic Diagram

The schematic diagram of the system is as illustrated in Figure 2. It is a sustainable solar system designed for running a tomato seed, pulp, and juice extractor for quality control. The system is monitored by an Arduino Uno microcontroller system.

The system is powered from a solar panel as a principal sustainable energy source. The panel power is fed to a battery via a charge controller to regulate the energy fed to the battery for the life span of the battery. The source energy must remain reliable as much as possible and cannot solely depend on sunlight during sunny days when it is limited.

The battery is an energy storage device and reserves the power for use later to ensure the system retains some levels of automation even when the live energy source is unavailable. It ensures the motor remains with power to run the extractor at all times. Before the energy from the panel is used to power the motor, it must be changed from direct current to alternative current, the standard current in an electric motor. The inverter reciprocates power from the system energy storage to operational devices.

The motor links the extractor and activates their functionality to sieve the tomato seed from the rest of the fruit, extract the pulp, and yield juice. The mechanical operation is designed to reduce seed breakages and maximize the amount of juice and pulp.

The quality sensors are supervisory and are controlled by an Arduino Uno microcontroller. The latter is an electronically programmable small computer designed to execute certain functions; the utilized sensors are the pH sensor placed in the extracted juice to regulate its sourness, which is equally vital in determining its safety. The UV artificial light is used to sterilize the system's interior to ensure safe conditions appropriate for producing tomato juice.

The pH sensor reading is transmitted to the Arduino Uno, which can rectify any discrepancies or signal the corrections to be repeated.

The UV light is often monitored during Arduino operation to activate at specific interval durations while the plant extractor runs to sterilize the pathogen without tampering with the quality of the juice.

These designs integrate a complete system suitable for running a tomato extractor, giving priority to quality and sustainability as major factors. The reducing of carbon emission and running cost due to solar panel and accommodating an arduino uno ensures the tomato juice meets health and taste requirements. It probably offers a versatile approach to the changes that might be envisioned

in the agricultural sector given the current sustainability and expectations in terms of quality and safety.

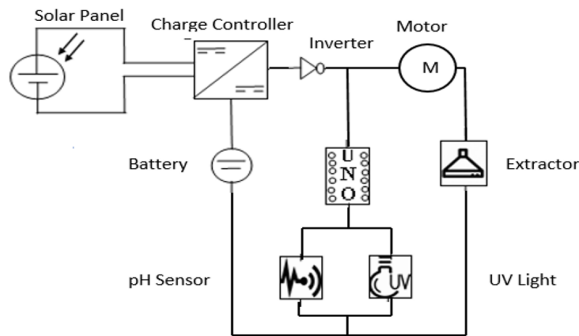


Figure 3. Schematic Diagram

Figure 3: Schematic Diagram

Process Flow Chart

Figure 4: The process flowchart outlines a tomato juice extraction and disinfection system using solar energy. This is an off-grid system — it works when you flip the switch on manually, then feeds power into the system from solar panels and a battery. Finally, the use of renewable energy makes sure that the whole system will operate sustainably and independent of traditional electrical power supply which helps it to make especially useful for off-grid or remote sites. After the system is activated, the extractor begins by extracting the seeds from the tomato pulp, followed a juicer that separates juice out of both pulp and skins. This improved separation process ensures that tomato components are separated into seeds, pulp/skins and juice so that the by-products (seeds and pulp) can be used for other applications to reduce waste like composting or animal feeding.

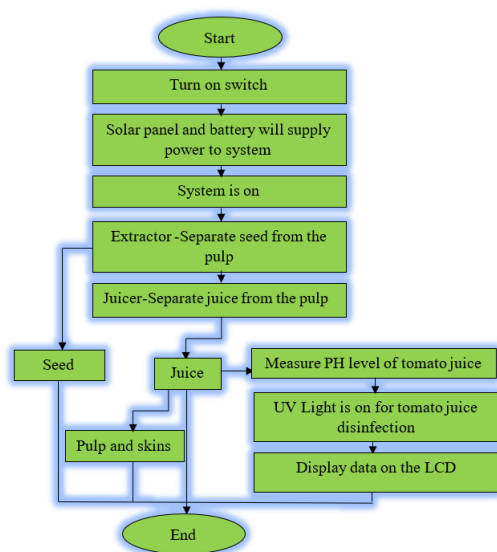


Figure 4: Process Flow Chart

Once juice is extracted, the system automatically determines the pH level of the tomato juice, which is a critical step to ensure that acidity of heated samples still meets safety and quality standards. This safeguard assures the quality and safety of the product. Once the pH is monitored, the juice passes through a disinfection system using UV light (an ecological and pesticide-free method to eliminate pathogens and bacteria); assuring that the juice is safe for consumption. This method not only is effective in preserving the juice characteristics but also respects modern food safety, especially for those people who want to avoid preservatives or chemicals.

The system includes a very user-friendly interface that displays important data, such as pH and operational status on an LCD display. Real-time monitoring of data helps the operators to monitor the performance of each system and make the required adjustments quickly to provide constant juice quality. After squeezing, disinfection and relevant data display the operation ends up with the system being re-set for the next cycle.

For example, a solar tomato juice extraction system is characterized by high efficiency and safety in design and operation with the sustainability benefits of using renewable energy sources. The system offers an eco-friendly and reliable method of juice production via the integration of renewable energy sources, automation of extraction process, accurate pH measurement for assurance quality and application using UV disinfection. In addition, the opportunity to process by-products such as seeds and pulp makes it relevant for a sustainable disposal of waste which makes it attractive for both small holders and bigger juice processing companies. The additional used the LCD display for monitoring, making it more convenient and simpler to operate while ensuring that can work at best performance in various environments.

RESULT AND DISCUSSION

Design and Fabrication

Dominating developing and constructing the Sun Sieving system's need to combine more elements to fabricate a stable, effective and simple device. This set up uses solar panels attached to a battery (i.e. buffer box), ensuring that it can work even in places with limited or no electrical supply at all. At the heart of this system is an extraction unit that aims to rapidly remove tomato seeds from its pulp, followed by a juicer to produce juice from the remaining pulp and skins. By separating the process of extracting the oil from other by-products like seeds and pulp, that gives opportunity for efficient recovery or disposal, ultimately contributing toward waste reduction. Once it is extracted, the liquid passes through a UV disinfection chamber which treats it using UV-C light. This process kills pathogens without chemicals, which preserves flavor and other characteristics of the juice.

It includes a pH sensor that constantly measures the acidity of the juice so ensure it is safe to drink. They are displayed on an LCD that notifies the operator in real-

time whether the juice meets safety standards by indicating its pH. All parts of the system are made up of durable, food-grade materials like stainless steel for extraction and commercial-grade tubing for transporting juice. The UV disinfection chamber is specifically designed to block the leakage of UV light, ensuring proper disinfection without exposing the user.

The design process begins with working on the frame and housing, after which we add solar power elements, extraction units and UV disinfection chamber. Each element is carefully tuned to ensure optimal operation, and the system is rigorously tested to validate end-to-end functionality under a variety of conditions. This resulted in a modular, ecological process and automated system for quickly processing safe and high-quality tomato juice. The design is simple to operate and maintain, making it ideal for small farms, rural areas, or companies that require an environmentally friendly and cost-effective option to produce juice.

Power Demands

The Sun Sieving system power consumption requirements are in addition to the energy needs of each component of the system. These requirements assist measure their solar panel and battery storage-based size by working up in evidence. The extractor motor which uses 746 Watts is the largest energy user in the system. The Arduino Uno R3, which implements the control logic for regulating the sensors and activating UVC light has total power consumption of at least 0.29 Watts in minimum mode. There is 4 watts of power that comes with the UVC lamp which plays an important role in tomato juice sterilization for consumption purposes. This translates to a total power consumption of 750.29 Watts in the system for these components.

The overall load determines the size of the solar power-generating and storage system. The solar panel array should have the capacity to generate or allocate more solar power to meet and exceed the need during most of the sunny parts of the day. The battery storage should also store sufficient power to the system to prevent failure due to insufficiency occasioned by missed shots or inefficiencies. The capacity of the solar panel and batteries should go beyond the stipulated, inefficient consumption and supply of solar power inelegance. The overall energy consumption during the Sun Sieving system operating cycle in terms of the motors operating duty cycle, UVC lamps on time, and the Arduino's utilization will determine this factor. Therefore, it should have a surplus in the energy preparedness appraisal. This will ensure dependability and robustness irrespective of the external factors mentioned.

Panel and Battery Sizing

The sizing for both the solar panels and batteries used in the Sun Sieving system is essential for its operation due to its daily operation for 6 hours and a total load of 750.29 Watts. Firstly, the size of the solar panel, the

energy requirement for the system's daily operation can be calculated as follows: considering it operates for 6 hours, the amount of energy used, is 4501.74 Watt-hours. The common inefficiencies of such systems of around 25% means that the rest of the energy needed would be around 6002.32 Wh. Hence, to meet this energy need, the solar array should have a capacity of around 1200.46 Watts considering an average of 5 peak sunshine hours daily. Using regular 250-Watt solar panels, this calculation would yield around 5 panels to provide the required electricity.

The sizing of the battery array can be done as follows: the daily energy storage demand would be the same as the energy supply need of 4501.74 Wh. However, to increase battery longevity and dependability accounting for the depth of discharge set at 50% for such batteries means the total battery capacity is around 9003.48 Wh. For a 24 V infrastructure utilized in medium-scale solar installations, the batteries would have a power capacity of around 375.15 ampere hours. Regular 12 V 100 Ah batteries of about 8 units would be needed to do this, keeping in mind that the 12 V batteries would be interconnected to become a 24-volt array to power the Sun Sieving even when there is no sunshine.

These calculations yield the solar panels and battery arrays' essential inputs used to power the Sun Sieving system. However, these numbers are estimates. In practice, the ideal metrics take into consideration factors such as the actual location of the solar wall, weather variations and durations of operation that could directly affect the final size. Therefore, the input of a solar energy expert would be essential in fine-tuning these metrics variably to ensure the system's optimal functionality and reliability.

The Sun Sieving System

As shown in Figure 5, the Sun Sieving system is developed using concrete design principles aimed at ensuring the manufacture of different standardized components, each designed based on exact measurements to facilitate the collection of tomato seeds, pulp, and juice. At the central point of the system are the skeletal constructs, which serve as the primary mechanical systems, pragmatic support, and localization of the other mechanical devices depending on their structural stability. The extractor is one of the key mechanical devices that is connected to the given skeletal structure, and it has a width of 45 cm. It features a 7 cm properly planned blade, which is connected to a tubular structure whose dimensions are 25 mm by 50 cm. The blade has a design speed of 800 rpm, which provides a complete frontal division and separation of the tomato fruits, tomato seeds, and base pulp. Importantly, its alignment and point-of-application angle is properly determined through exact measurements to ensure maximum performance.

Below the extractor is the seeder, and it consists of an internal spiral blade plane sheet. This component facilitates the direction of divided seeds towards the exit, and it ensures that the vital components for processing

are properly separated and directed out. One of the vital connecting components positioned near the entrance of the starting rate of the unprocessed tomatoes to the extractor is the hopper. The rest of the pulp is directed towards the juicer through a 16 cm long and 5 cm diameter runner, which is responsible for grinding the pulp and processing it to release the raw juice. This entire process is surrounded and guided by tailor-made bearings, and pulleys customized to suit the system's mechanical state and functionality levels, thereby ensuring the optimal movement of the physio-structured components of the systems.

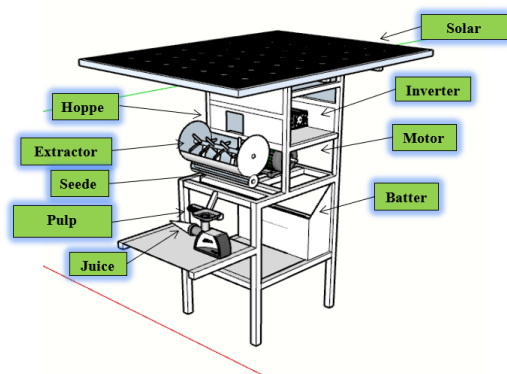


Figure 5: The Sun Sieving System

Figure 5 provides the physical layout of the components developed to drive the Solar Seam Sieving Systems, as well as the engineering design processing that ensured the development of agricultural processing equipment that supports and maintains a mechanism that can defy other forms of agriculture.

Integrated Control System for the Sun Sieving Solar-Powered Extractor

The Sun Sieving system utilizes the Arduino UNO R3 microcontroller, which is essential for automating the juice extraction process while ensuring quality control and food safety. The system's program is engineered to perform two essential functions: utilizing UV light for the sterilization of tomato juice and the ongoing monitoring of the juice's pH levels.

A float sensor that detects juice in the container triggers ultraviolet light, a high-efficiency sterilization method. Once the juice is detected, the float sensor triggers a relay which powers the UV light as necessary. This ensures that UV sterilization is performed only when needed, effectively eliminating broad-spectrum microbial pathogens (bacteria, viruses and fungi) enhancing safety and juice shelf life. Syed *et al.* (2019) demonstrated UV-light successfully in eliminating microbial flora while enhancing shelf life of orange juice at minimal cost and without chemical additives to destroy microflora and then preserve organic components nutrients, a helpful

sterilizing method.

The tomato juice quality is measured using a pH sensor [5]. Once the sensor senses juice in the tank, this specific step is activated to continue monitoring pH levels throughout the system. Tomato juice normally has a pH varying from 4.05 to 4.65. Maintaining this pH range is crucial in the production of good quality, safe to consume juice.

The entire system was programmed and debugged to improve levels of UV light and pH sensors actuation. This involved assessing various process parameters, adjusting microscopic float sensor sensitivity, calibrating the pH sensor to ensure readings and adjusting the operation time/intensity of UV light. The objective was to design an automated system that can enhance performance and reliability of Sun Sieving extractor during the extraction process so that desired quality and safety assurance in tomato juice produced is guaranteed.

Test the Functionality of the Sun Sieving Machine

The tomato extraction process is shown in Figure 6. The Sun Sieving system works efficiently, and it can separate the tomatoes into three components: pulp, seeds, and juice. Three containers are illustrated in the diagram, and each contains one of the extractions.

The tomato pulp, a thick and fiber stuff that is the leftovers after the seeds and juice are removed sits in a container on the left. The orange-red color highlights the rich natural pigmentation existing in the flesh itself, which is abundant in lycopene — a strong antioxidant. The pulp can be employed in various culinary uses such as processing it into sauces or pastes, or used as a base for soups and stews, enhancing the nutritional profile of food products and their taste.

In the main container we have the tomato seeds covered in a gelatinous substance coming from the locular jelly of the tomato. Their clear distinctive separation suggests that this system is perfectly tuned for the preservation of embryo viability making them suitable for cultivation or further processing into tomato seed oil. This oil is known for its health benefits and culinary use.

The last container on the right is tomato juice, a seedless pulp-free liquid that is clear. The deep red color of the juice indicates that there is not much oxidation, which helps preserve a level of nutrients and flavor. The liquid can be consumed as-is, made into bottled juices or concentrates, or act as a base for cocktails and other beverages.

This systematic arrangement of components highlights Sun Sieving System capability for tomatoes processing and, on the other hand, shows how a waste separation method can lead to an almost zero waste production process. Each byproduct is then prepared for further processing or direct use, promoting sustainability and ensuring the utility of each part process. The Sun Sieving system represents agricultural processing that minimizes the carbon footprint of production while maximizing nutrients in essential foods, which is critical to optimizing efficiency across food processing and agriculture sectors

where emissions have accounted for over 70% of total greenhouse gases emitted.



Figure 6: Outputs of the Sun Sieving Tomato Processing System - Separated Pulp, Seeds, and Juice

Table 1 shows an overall test of the Sun Sieving performance across a variety of operational parameters based on six different but similar experiments. We present a novel semi-automated extraction of *Solanum lycopersicum* seeds, pulp and juice from fruit that incorporates an Arduino microcontroller and solar energy into the operational system. Sun sieving system design itself, combining conserving ecology with the effective goodness and efficiency of operations as well as juice quality by portfolio concept utilizing modern technologies such as pH meters' isometric electromagnetic waves value and UV for food sterilization.

The steady pH range across all experiments (4.00-4.50) demonstrates the capacity of the system to keep the juice within optimal tomato acidity level. Since the juice sold in bottles is more likely to spoil than the fresh one, ensuring

Table 1: Performance Evaluation of the Sun Sieving System Across Multiple Trials: pH Monitoring, UV Sterilization Efficiency, and Processing Times

Trial No.	pH Level	UV Light Sensor	Yield of Juice (L)	Seed	Processing Time (second)		
					Pulp to Juice	Juice	Tomato Pulp and Skins
1			1.30	110.0	120.0	150.0	180.0
2	4.00 - 4.50	On	1.30	110.0	120.0	150.0	180.0
3	4.00 - 4.50	On	1.30	110.0	120.0	150.0	180.0
4	4.00 - 4.50	On	1.30	110.0	120.0	150.0	180.0
5	4.00 - 4.50	On	1.30	110.0	120.0	150.0	180.0
6	4.00 - 4.50	On	1.30	110.0	120.0	150.0	180.0

that the cold-pressed juice has passed relevant safety tests and taste reliability tests is a critical necessity. Tomatoes have a pH range on average from 4.05 to 4.65 according to ScienceDirect (2018). These findings agree with our results and further highlight the capability of the system to maintain tomato juice at its natural acid degree without additional acidification (Kosters *et al.*, (2009).

This system of sun sieving has an automatic UV light sensor that increases food safety and product storage life. When the juice is sensed in the container, UV light works automatically – it decontaminates the juice by destroying different microbiological pathogens, including viruses, bacteria (certain species), all fungi and yeast as well as spores. This is illustrated in research by Kosters *et al.*, (2009), prolongation of shelf life by UV providing evidence for the benefit of maintaining freshness over time via UV sterilization of fresh orange juice. According to Science Daily (2018), this method successfully reduces microbial flora and is a mild process causing significant reduction in nutritional quality while slight changes of juice properties for shelf-life extension. The versatility of the method for juice preservation is illustrated by sun sieving (Sieving) [46].

Across all trials, the system yielded 1.3 liters of juice, achieving the established target in an acceptable time frame. It provides seed separation, pulp juice conversion, processing of juice and good differentiation between processed tomato pulp and peels making it usable for

demonstration purposes. The outcomes showed the most productive productivity efficiency. The time points of interest included seed handling at 110 s, juice processing at 120 s, second-round juice processing at 150 s, and pulp-processing equipment operation (180 s).

CONCLUSION

This is achieved by integrating renewable energy technology with an open-source agricultural processing method, as exemplified by the design, build, microcontroller integration and successful final testing of the Sun Sieving project. The entire system, which was made up of structural framework, the extractor itself and all additional components required to assemble the apparatus such as a seeder, hopper & juicer were designed and manufactured with absolute precision to ensure that it would all fit together correctly and gain a solid foundation upon which to rest. The high performance of pure results was necessary for the system to separate tomato seeds, pulp and juice effectively.

The addition of an Arduino Uno microcontroller significantly enhanced the system's productivity by playing a crucial role in controlling both pH sensor and UV light sensor. The combination of its ensured quality and safety features; essentially, if the float sensor detects juice, it automatically turns on the UV light. This automated procedure validated the capability of the

system to autonomously operate and efficiently uphold strict food safety protocols by eliminating potential microbial hazards.

All components in the Sun Sieving system worked in unison to generate repeatable results in five separate performance tests. The tomato juice showed high pH measurements throughout the research, meaning that there was no compromises in quality. Minimum design requirements of the system were confirmed by consistent separation of seeds and pulp in each trial.

This project showcases the synergy of solar integration with innovative technology to enhance the efficiency and sustainability of food processing operations. Building a system that met or exceeded performance benchmarks could only be accomplished systematically and iteratively across multiple project phases. This design offers a scalable and modular tomato-processing device, which can be considered as an innovative step towards sustainable agricultural technology providing a base for future systems in this direction.

REFERENCES

- Abd El-Salam, M. F. M., Mohammed W. K., Baiomy M. A. & Taie A. A. M. (2019). Using of solar energy to operate milling machine. *Misr J. Ag. Eng.*, 36 (2): 391 – 410, DOI: 10.21608/MJAE.2019.94621
- Ahmed M. I. Soliman, Mahmoud A. El-Nono, Mubarak M. Mustafa & El-Amin M. Arif (2017). Manufacturing a tomato seed extracting machine. *Misr Journal of Agricultural Engineering* 34(1):65-82, DOI:10.21608/mjae.2017.96880 https://mjae.journals.ekb.eg/article_96880
- Alemu Degwale Yimer, Tiru Tesfa & Belete Meseret (2020). Effect of seed extraction methods of tomato on physiological quality of seeds and seedlings. DOI:10.21203/rs.3.rs-49268/v1 <https://doi.org/10.21203/rs.3.rs-49268/v1>
- Alonzo A. Gabriel, Michael Louie C. Aguila & Kimberly Anne M. Tup (2015). Application of ultraviolet-c radiation to inactivate acid-and-desiccation stressed salmonella enteric a in young and mature coconut liquid endosperm mix beverage. *Food Control* 51: 425-432, DOI:10.1016/j.foodcont.2014.12.007 <https://doi.org/10.1016/j.foodcont.2014.12.007>
- Aniceto, José P. S., Vitor H. Rodrigues, Inês Portugal, and Carlos M. Silva (2022). Valorization of tomato residues by supercritical fluid extraction. *Processes* 10, no. 1: 28. <https://doi.org/10.3390/pr10010028>
- Arun V. Prasath, Rajkumar S.P. & Aarthy Viswanath (2017). Development of solar tunnel dryer for drying tomato (*lycopersicum esculentum*) slices. *Int. J. Pure App. Biosci.* 6 (2): 1368-1373 (2018) <https://dx.doi.org/10.18782/232-7051.2916>
- Asaad Rehman Saeed Al-Hilphy, Abdul-Hadi K. Ahmed, Mohsen Gavahian & Ho Hsien Chen (2022). Solar energy-based extraction of essential oils from cloves, cinnamon, orange, lemon, eucalyptus, and cardamom: A clean energy technology for green extraction. *Journal of Food Process Engineering* 45(13), DOI:10.1111/JFPE.14038 <https://doi.org/10.1111/jfpe.14038>
- Debbie Butch Pequena, Arthur Fajardo, Omar Zubia, and Roger Luyun Jr. (2020). Development of an automated drinking system using microcontroller for broiler production. ISSN: 2186-2311, Environment 2020: Official Conference Proceedings <https://doi.org/10.22492/issn.2186-2311.2020.2>
- Harpreet Singh, Sanjeev K. Bhardwaj, Madhu Khatri, Ki-Hyun Kim & Neha Bhardwaj (2021). UV-C radiation for food safety. An Emerging Technology for Microbial Disinfection Of Food Products. *Chemical Engineering Journal*, vol. 417, 128084 <https://doi.org/10.1016/j.cej.2020.128084>
- Kabir M. H., Humna Saeed, Danladi Drambi Usman & Adamu A., (2021). Design, construction and performance evaluation of a motorized tomato slicing machine. *IOSR Journal of Engineering* 11(11):18-25
- Kamaldeen O. S. Arowora K.A., Abioye J.S. & Awagu E.F. (2016). Modification of manually operated tomato slicing machine. *International Journal of Engineering & Technology* 2(1), DOI: 10.14419/ijet.v2i1.569 <https://doi.org/10.14419/ijet.v2i1.569>
- Kosters, P.S.R., & Waldron, K.W. (2009). 15 - Production of high-value functional vegetable juices from food co-products, In Woodhead Publishing Series in Food Science, Technology and Nutrition, Handbook of Waste Management and Co-Product Recovery in Food Processing, Woodhead Publishing, Pages 376-390, ISBN 9781845693916, <https://doi.org/10.1533/9781845697051.3.376>.
- Mahjabeen Khan, Murray McDonald, Kaustubh Mundada & Mark Willcox (2022). Efficacy of ultraviolet radiations against coronavirus, bacteria, fungi, fungal spores and biofilm. *Hygiene* 2022, 2(3), 120-131 <https://doi.org/10.3390/hygiene2030010>
- Miriam Fabiola Fabela-Moron, Juan C. Cuevas-Bernardino, Teresa Ayora-Talaver & Neith Pacheco (2019). Trends in capsaicinoids extraction from habanero chili pepper (*capsicum chinese jacq.*). *Recent Advanced Techniques, Food Reviews International*, 36:2, 105-134, DOI:10.1080/87559129.2019.1630635 <https://doi.org/10.1080/87559129.2019.1630635>
- Nel Panaligan, Liza Cudera, Jullinie Love Oda and Roy Amante (2021). Android based agricultural insect trap monitoring system using solar panel and arduino technology. <https://dx.doi.org/10.2139/ssrn.3780518>
- Papade C.V., Vallal S.L. & Dornal N.D. (2016). Literature review on solar operated coconut oil extraction machine. *International Journal of Engineering Trends and Technology (IJETT)*, V36(1), 10-13 JUNE 2016. ISSN:2231 5381.DOI:10.14445/22315381/IJETT V36P20.www.ijettjournal.org
- Putra Jaya, Hendra Hidayat, Delsina Faiza and Almasri Almasri (2022). The automatic onion cutter using arduino uno as control system tool. *INVOTEK: Journal Inovasi Vokasional Dan Teknologi*, 22(2), 97-106.

- <https://doi.org/10.24036/invotek.v22i2.1030>
Rulin Swastika, Efi Rohman, M. Agus & Badruzaman Al Khoir (2022). Prototype design of honey extractor machine using arduino microcontroller with internet of things (iot) model. *Journal TAM, vol. 13*; E ISSN:2579-4221; P ISSN: 2339-1103, pp.26-33 <https://ojs.stmikpringsewu.ac.id/index.php/JurnalTam/index>
- Sneha, N., Patil, B.M. (2022). The Impact of UV-C Treatment on fruits and vegetables for quality and shelf-life improvement using internet of Things. In: Nayak, J., Behera, H., Naik, B., Vimal, S., Pelusi, D. (eds) *Computational Intelligence in Data Mining. Smart Innovation, Systems and Technologies, vol 281*. Springer, Singapore. https://doi.org/10.1007/978-981-16-9447-9_18
- Syed, Qamar Abbas & Jabeen, Ifra & Shukat, Rizwan. (2019). Effect of ultraviolet light on fresh orange juice properties and shelf life.
- Villanueva, EE (2018). An overview of recent studies of tomato (*solanum lycopersicum* spp) from a social, biochemical and genetic perspective on quality parameters. Alnarp-Sweden: *sverigeslantbruksuniversitet*.
- Wedashwara W. Jatmika A. H., Zubaidi A. & Arimbawa I. W. A. (2021). Solar powered IoT based smart hydroponic nutrition management system using FARM. *IOP Conf. Ser.: Earth Environ. Sci. 913* 012010, DOI 10.1088/1755-1315/913/1/012010 <https://iopscience.iop.org/article/10.1088/17551315/913/1/012010>