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Development and Innovation of Extractor For Malunggay (*Moringa oleifera* Lamk)

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Abstract

This study aimed to develop and innovate an extractor for malunggay to solve its laborious and tedious processing and for product and by-products development. Particularly, innovation of existing malunggay juice extractor was done and tested in terms of efficiency, capacity, extraction time, losses and power requirement, and its technical and economic viability. The extractor was innovated for extracting malunggay juice and other similar commodities. Testing of innovated extractor was highly significant in terms of extraction time, volume of extracted juice, and percent recovery of juice extracted compared to the manual extraction process. The juice extraction of the malunggay using the innovated extractor showed a capacity of 5.5 kg/hr to almost 19 kg/hr using matured and young leaves and stalks. The mean juice recovery is 62%. The innovated extractor for malunggay has higher efficiency and capacity but has lesser processing time, losses, and power requirement. The malunggay extractor is economically viable and feasible. The extractor could extract juice from malunggay, and its meal could be converted into powder and tea and gain a minimum of ₱62/kg of malunggay. It has a return on investment of 34.11% with a payback period of 2.1 years. The fabrication of the prototype of "Agiseparator," downsizing of the equipment, technology commercialization, adoption of a backyard planting for malunggay; health impact dissemination, determination of nutrient retention and loss during processing, and development of more products from malunggay are recommended.

Keywords: *malunggay, zero waste, malunggay processing, malunggay juice, herbal products*

Introduction

The Philippines is home to a variety of plants with medicinal values. Among them are the regionally important *Canarium ovatum* Engl (General & Guerrero, 2017), the common rural fruit tree *Psidium guajava* L. (Naseer et al., 2018) and the *Moringa oleifera* Lamk (Anwar *et al*., 2007).

Malunggay (*Moringa oleifera* Lamk) is one of the world's most useful plants. It is used as food, effective flocculants or water treatment, antibiotic, source of oil, and coagulant for turbid waters. It is cultivated in all countries of the tropics. It is easy to plant and is available year-round (Anwar *et al*., 2007). In the Bicol region, there are no records for the plantation of malunggay. However, backyard production is noticeable in barangays even in town centers. These backyard plantations, if being bought to be processed into powder, will inspire more farmers to plant malunggay which will increase its production (Sandoval *et al*. 2013).

Malunggay is also called mother's best friend and miracle vegetable by many who know malunggay's beneficial uses (Price, 2007). One cup of cooked malunggay leaves (approximately 100 g) contains 3.1 g. protein, 0.6 g. fiber, 96 mg calcium, 29 mg phosphorus, 1.7 mg iron, 2,820 mg ß-carotene, 0.07 mg thiamin, 0.14 mg riboflavin, 1.1 mg niacin, and 53 mg ascorbic acid or vitamin C. The antioxidant activity of malunggay is about 71%, with µ-tocopherol (vitamin E) equivalent of 45 (Babu, 2000). It is an excellent source of vitamin A and B, and minerals such as calcium and iron (Owusu et al., 2008). It is even an excellent source of protein, being higher than the amino acid pattern of Food and Agriculture Organization-reference protein, yet contains very low fat and carbohydrates. The leaves are incomparable as a source of the sulfur-containing amino acids methionine and cystine, often the natural minerals humans lack (Broin, 2006).

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With this much benefit to the human body, malunggay now is a luminary. The moringa industry in the Philippines is slowly being developed with the assistance of the government and private sectors (Palada, 2015).

Studies are undertaken to process this commodity into powder as food additive, oil, fuel, flavoring, medicine, tea, and other products. However, the lack of processing technologies for malunggay hinders processors to invest in improving the processing of this commodity, thereby creating so much waste in the process. Further, the present process affects the taste of malunggay, making it bitter when added to food. The most tedious in the process is the juice extraction. It usually recovers low volume of juice, which is the most important by-product of the malunggay.

The innovation and development of juice extractor for malunggay will pave way to the development of other byproducts from malunggay and the creation of zero waste processing technology for the said commodity. Extraction of the malunggay juice will result in the creation of high-grade malunggay juice and powder production, which may be used as flavoring, additive, and ingredient on food, drinks, and medicine. Furthermore, the utilization of other parts of malunggay may be explored thereby creating a zero waste processing technology as an upshot. This will result to significant increase of income of the farmers and entrepreneurs, new product for consumers, and a springboard for researchable area for researchers and professors.

Thus, this study aimed to develop and innovate an extractor for malunggay and similar commodities for volume production of juice and powder. Specifically, this research aimed to (1) innovate existing juice extractor for extracting malunggay; (2) test and evaluate its performance in terms of efficiency, capacity, time, losses and power requirement; and (3) determine its technical and economic viability.

Materials and Methods

Technology Verification

Technology verification was done to generate data from the extraction of juice from malunggay leaves and stalks. The extraction time, process, tools, and materials used was documented to be the basis for technology intervention.

The technology verification was done with three processors engaged in processing malunggay. The verification tests established the data and process for the manual and semi-manual extraction of malunggay juice. Three maturity levels of malunggay were used in the verification test to establish the finest ripeness of malunggay that could be extracted: two-week-old malunggay stalk, four-week-old malunggay stalk, and six-week-old malunggay stalk. Fifty (50) stalks of malunggay were utilized in each maturity level. The verification tests were done in single and in bulk. Milling of malunggay was not included in the verification since the meal of extracted malunggay leaves were considered as wastes including its stalks.

Ex-Ante Analysis/Technology Intervention

Ex-ante analysis was done in the extraction of juice from leaves and stalks of malunggay. Simulation of the manual processing was to study the possible technology intervention to be done to the tedious process. Creation of a mature, and easy way of malunggay juice extraction was done. As a general scheme, it is to create product and by-products from extraction of juice from malunggay with minimal to zero waste.

Innovation and Development of Prototype Model

Existing machine was innovated to suit for extracting malunggay and similar commodities. The innovation was based on the problems that the machine encountered during it preliminary testing for malunggay extraction. The innovation also included the simplicity and portability or ease of transport, use of locally available materials, affordable cost, capacity, efficiency, and the economics of operation.

The conceptualized design was translated into working drawings and plans with specifications and costs. Consultation with the Bicol University Polangui Campus (BUPC) experts and KOLBI engineers was done for suggestions on the final design of the prototype model. The machine was fabricated by KOLBI, following the design and specifications. Materials for fabrication was procured in the local market or where the materials were available.

Field Testing and Evaluation

The innovated machine was tested for the extraction of leaves and stalks of malunggay. The machine was evaluated as to its operation, running condition, and parts coordination. Defect in the operation was noted and was used to further modify the extractor. The modified model was tested and evaluated using the

above-mentioned parameter. All cost incurred during the fabrication and modification of the machine was recorded to determine the actual machine cost.

Field testing of the developed machines was done in an identified field site using the following criteria: process, capacity, efficiency, recovery, losses, and economics of the process. Results of the test was collected and properly recorded. Tables and diagrams were generated for ease in the visualization and analysis of data. Machine performance was evaluated and analyzed using descriptive statistics.

Results and Discussion

Technology Verification

Existing extractor technology uses the manual method and follows the process shown in Figure 1. The technology verification test of manual extraction was done using cloth. The extraction of juice from leaves took 10, 9.3, and 8.7 min for the 2-week, 4-week and 6-week old, respectively, while it took 13, 16.2, and 22 min to extract the juice from the stalk for the respective maturities. Verification test for manual juice extraction is shown on Table 1. Total juice recovery was established at 10.37% for 2-week old, 12.93% for 4-week old, and 15.06% for 6-week old malunggay samples.

In the technology verification, the extractor reached an extraction capacity of 5.42 kg/hr for the leaves and 27.76 kg/hr for the stalk. This is due to the chopper, which is not suitable for malunggay leaves since the leaves are stock on its blades and do not fall in the chamber. Once the leaves fall into the chamber, it clogs the stoppers attached to the walls of the chamber that makes the machine unable to extract the juice from leaves. Further, the existing extractor has an extracting efficiency of 53.67% for the malunggay leaves and 91.67% for malunggay stalk. Result of testing the ginger extractor for extracting malunggay juice is presented in Table 2.

Ex-Ante Analysis/Technology Intervention

Based on the verification tests conducted, a process flow for processing malunggay was established. According to the process flow, the most tedious method of the processing is the juice extraction. Therefore, innovation and development of juice extractor for malunggay is needed to mechanize the process to obtain higher extraction capacity, greater juice recovery, and the zero-waste process.

Testing of the existing extractor has problems in the hopper and in the chamber; thus, the need to redesign the extractor to suit to malunggay leaves and similar commodities was done. As a result, a zero-waste processing technology was introduced due to the development of extracting machine for malunggay. The process flow for the processing of malunggay with leaves and stalk separation is shown in Figure 2, and the process flow for the processing of malunggay without leaves and stalk separation is shown in Figure 3.

Machine Design, Fabrication, and Testing of Moringa Juice Extractor

The design of malunggay juice extractor was based on the ginger juice extractor and mill. The existing ginger extractor and mill shows low capacity and efficiency in extracting the malunggay leaves. This is due to the hopper that consist of chopper that produces losses in malunggay test samples during operation, and the stopper in its chamber that obstructs the malunggay during extraction process.

Therefore, the innovation in the existing extracting machine was done by modifying its hopper and extracting chamber to suit extraction from malunggay

Table 1. Verification test for Manual Juice Extraction of *M. oleifera* Leaves and Stalk

Maturity of Moringa Stalks and Leaves	No. of stalks (pcs)	Weight (g)	Juice Extraction Time (min)		Volume of juice extracted (ml)		Extraction Recovery (%)	
			Leaves	Stalk	Leaves	Stalk	Leaves	Stalk
2-week old	50 stalks	1029	10	13	101.50	5.38	9.86	0.52
4-week old	50 stalks	1195	9,3	16.2	150.39	4.18	12.58	0.35
6-week old	50 stalks	1257	8.7	22	186.48	2.77	14.83	0.22

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Table 2. Testing Ginger Extractor for Extracting Juice of Malunggay

Parameters	Material Tested	
	Malunggay Leaves	Malunggay Chopped Stalk
Machine capacity (kg h-1)	5.42	27.76
Extracting efficiency (%)	53.67	91.67
Extracting recovery (%)	61.14	93.57
Juice Splatting Loss (%)	0.12	1.23
Meal Pulsating and Residual Loss (%)	3.14	3.95

and other similar commodities. Fabrication of machine was done at Tropics Agro Industry in Naga City, which is capable of crafting the machine. It carefully followed the design drawing with its measurements. Available local food grade materials were used in the fabrication of the machine. The machine was composed of the hopper, extracting chamber, adjuster, transmission, frame, and primemover.

The design of the machine was based on the following: the hopper is set at 43º slope since the angle of friction of *Moringa* leaves was at 41.67º for fresh leaves and 34.67º for dried leaves. The machine chamber was based on the characteristics of the *Moringa* leaves in contact with metal. The dimension of the hopper and capacity of the machine was based on the weight and bulk density of the test materials. Machine efficiency was based on the available moisture content of the *Moringa* leaves. The summary of the physical characteristic of the fresh and air dried *Moringa* leaves is shown on Table 3.

Description of the Moringa Extracting Machine

As shown in Figure 4, the *Moringa* extractor was designed to mechanize the extraction process of *Moringa* to achieve high capacity and efficiency of the process. The 80-kg extracting machine occupies a floor area of 79 cm x 40 cm. The machine is of stainless metal construction, and is composed of seven major parts namely: (1) hopper, (2) extracting chamber, (3) extracting plate and adjuster, (4) meal discharging plate, (5) juice discharging plate (6) transmission, and (7) frame. It is of simple design for ease of assembly and disassembly, as well as for ease of operation and maintenance. It can also be operated by a single person. Its technical specifications are shown on Table 4.

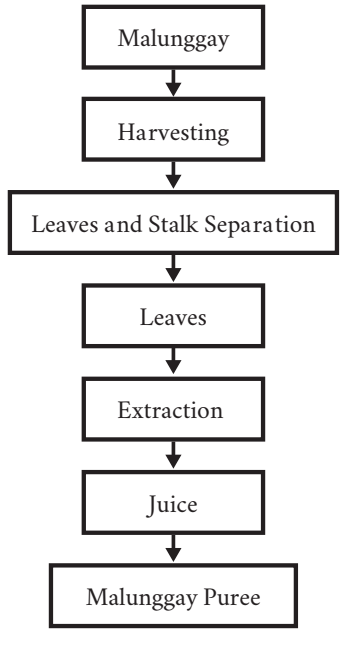

Figure 1. Process Flow of Manual Processing Malunggay

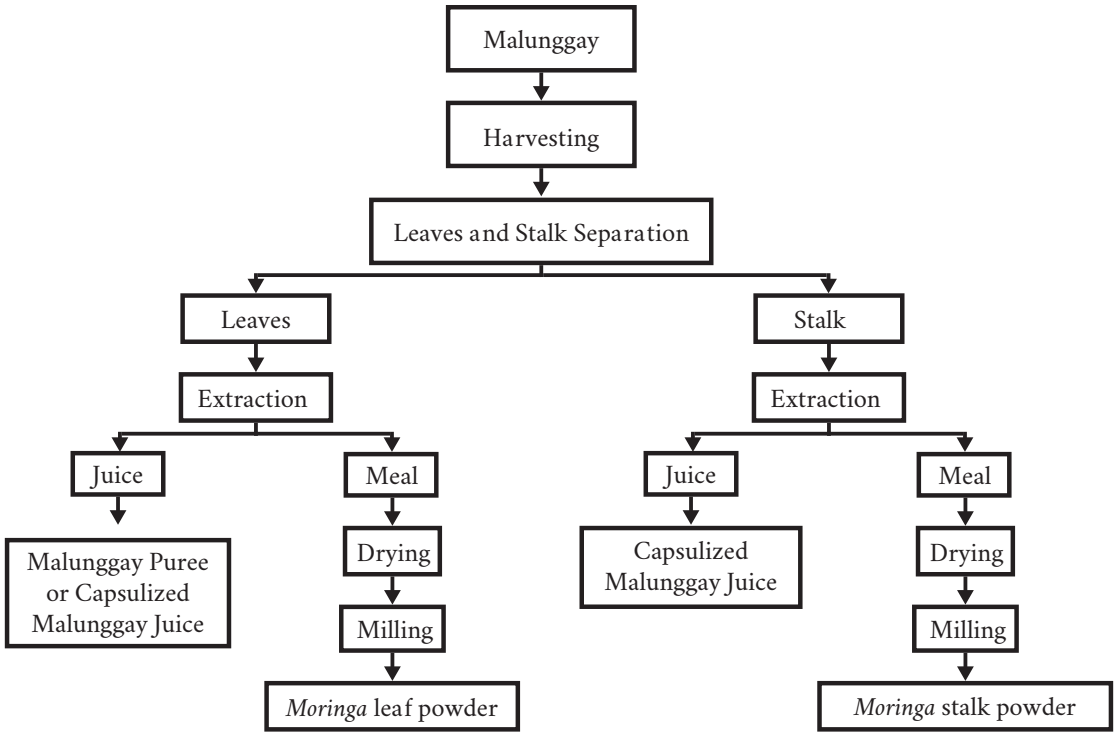

Figure 2. Process Flow for Processing Malunggay with Leaves and Stalk Separation

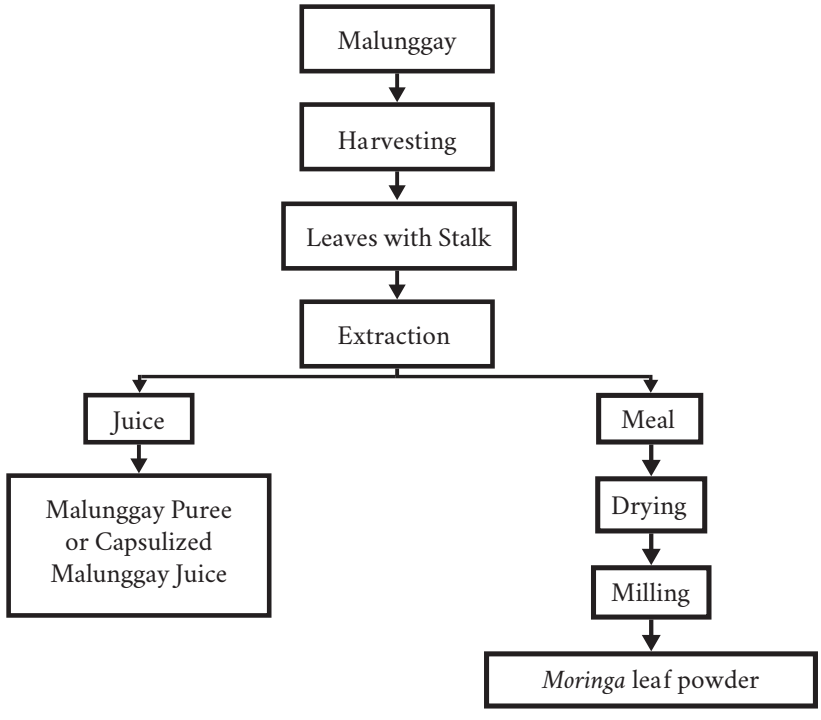

Figure 3. Process Flow of Processing Malunggay without Leaves and Stalk Separation

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Figure 4. Perspective view of the Malunggay extractor

The hopper of the malunggay extracting machine was designed to accommodate 900 cm^3 of materials without any chopper attached on it. It is where the leaves, stalk, or the malunggay bundles are loaded, and is made of 1.5 mm thick stainless sheet. It has a 43˚ inclination and is attached on top of the extracting chamber.

The extracting chamber of the malunggay extracting machine is composed of a screwder, a chamber without stoppers and is covered by extracting plate with adjuster at its end side. The extracting chamber is made of stainless sheet with holes at its bottom.

The meal discharging plate of the malunggay extracting machine is a 20 cm x 14 cm rectangular plate attached at the end of the extracting chamber where the meal of the extracted *Moringa* leave pass through.

The juice discharging plate of the malunggay extracting machine is a 30 cm x 25 cm rectangular plate with chute at its obverse. It is attached at the bottom of the extracting chamber where the *Moringa* juice is collected and pass through.

The transmission of the malunggay extracting machine includes the gear assembly, primemover, and the belt attached to pulleys that drives the extracting chamber. It is enclosed with GI sheet frame to protect the machine operator. The frame of the malunggay extracting machine is composed of angle bars that holds the extracting chamber, hopper, gear assembly, and primemover.

Operation of the Moringa Extracting Machine

The following are the steps in operating the machine:

1. Place the machine on a stable and level ground with sufficient working space before the operation.

Table 3. Summary of the Physical Characteristic of Fresh and Air-Dried *Moringa* Leaves

Properties	Materials	
	Fresh	Air-dried
Average dimension of a midrib with leaflets		
Length (cm)	45.00	43.7
Width (cm)	35.00	20.33
Weight of midrib bundle (g)	250.00	180.00
Moisture content	72.40	47.50
Bulk density (g cm^{-3})		
Unbundled midribs	0.030	0.017
Bundled midribs (15 pcs/bundle)	0.010	0.009
Leaves	0.365	0.400
Angle of friction (in degree)		
Stainless sheet	41.67	34.67
G.I. sheet	33.33	29.33
Wood	46.33	40.00
Angle of repose (in degree)	20.05	38.00

Table 4. Technical Specifications of the Malunggay Extracting Machine

Parameter	Specification
Extracting type	Screwder type cylinder
Commodity	Malunggay
Machine Specifications	
Overall length (cm)	79
Overall width (cm)	40
Overall height (cm)	130
Overall weight (kg)	80
Operating Characteristics	
Machine capacity (kg/h)	35.58–38.12
Extracting efficiency (%)	96.10–98.12
Extracting Recovery (%)	91.16–95.67
Juice Splatting Loss (%)	1.02–1.26
Meal Pulsating and Residual Loss (%)	3.68–7.51
Machine cost	PHP 240, 000.00

2. Install the component parts of the machine which are dismantled during transport.
3. Check the different parts of the machine and make the necessary adjustments.
4. Start the motor after securing the connections.
5. Load the prepared raw material into the machine. Make sure that when loading the leaves should be properly guided into hopper of the machine.

Principles of Operation

In the operation of machine, the first thing to do is to prepare the materials to be extracted. Malunggay leaves will be separated from its stalk to produce a good and sweet malunggay juice. The machine should be started before putting the materials in the hopper. The extracting chamber must move in counterclockwise direction. Two (2) kg of malunggay leaf detached from its stalk should be put into the hopper by the operator. The operator should monitor and ensure that the raw materials are properly placed into the hopper. After the malunggay is placed in the hopper, it will start to fall in the extracting chamber. Once the material reached the end point of the extracting chamber, its juice will be extracted by screwder and the extracting plate by grinding and pressing method. The operator repeats the process for continuous operation.

Performance Evaluation of the Malunggay Extractor

Machine testing was done at the Agricultural and Biosystem Department of Bicol University College of Agriculture and Forestry, Guinobatan, Albay. Testing of the machine was done in three trials using three maturity levels and two raw materials from malunggay to obtain an acceptable result in terms of capacity (kg/h), efficiency (%), recovery (%), and losses (%). The three maturity levels that were tested in the extractor were three-week-old, four-week-old, and five-week-old malunggay leaves, and malungay leaves with stalk.

Table 5 summarizes the performance of the malunggay extractor along various parameters. There was no significant difference at 5% level of significance among the malunggay maturity in all parameters tested.

During the extracting operation, juice splatting and meal pulsating losses were observed and was measured. Losses were determined by weighing the meal and juice recovered. As shown in Table 6, the highest average

Table 5. Performance Evaluation of the Malunggay Extractor

Raw Material	Machine Capacity (kg/hr)				Extracting Efficiency (%)				Extracting Recovery (%)			
	3-week old	4-week old	5-week old	Mean	3-week old	4-week old	5-week old	Mean	3-week old	4-week old	5-week-old	Mean
Malunggay Leaves	35.58	36.89	38.12	36.86	98.12	97.40	96.94	97.47	94.18	95.67	92.93	94.26
Malunggay Leaves with Stalk	35.91	35.98	35.53	35.81	96.15	97.57	96.10	96.61	95.15	92.37	91.16	92.89
Mean[1]	35.74*a*	36.44*a*	36.82*a*	36.34	97.14*a*	97.48*a*	96.52*a*	97.04	94.66*a*	94.02*a*	92.04*a*	93.58

[1]*Means followed by common letter are not significantly different at 5% level (DMRT)*

Table 6. Performance Evaluation of the Malunggay Extractor

Raw Material	Juice Splashing Loss (%)				Meal Pulsating and Residual Loss (%)			
	3-week old	4-week old	5-week old	Mean	3-week old	4-week old	5-week old	Mean
Malunggay Leaves	1.26	1.14	1.10	1.17	4.52	3.19	5.47	4.39
Malunggay Leaves with Stalk	1.12	1.19	1.02	1.11	3.68	6.29	7.51	5.83
Mean[1]	1.19*a*	1.16*a*	1.06*a*	1.14	4.10*a*	4.74*a*	6.49*a*	5.11

[1]*Means followed by common letter are not significantly different at 5% level (DMRT)*

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of 1.17% was computed for juice splatting loss for the malunggay leaves. It also revealed the highest splatting loss for the three-week-old malunggay. Nevertheless, no significant difference at 5% level of variation was computed.

Further, the highest mean percentages of meal pulsating loss was observed for malunggay leaves with stalk at 5.83 as affected by the fibrous five-week-old malunggay with the highest 6.49% meal pulsating loss.

Socio-Economic Implications

The innovated extracting machine for malunggay creates juice products and meal by-product. The juice can be packaged to a bottle for marketing, the meal can be dried and subjected to milling and be packaged as flavoring to pastries and baked goods, and the waste in milling may be packaged into tea. This creates a zero waste model technology.

The innovated extractor is now ready for promotion and adoption by the processors and targeted clienteles. To provide a macro-scenario showing the economic impact of processing. If the extracting machine will be utilized in around 7 h/day with a capacity of around 35 kg/hr, it could extract the juice of about 58,800 kg of malunggay/yr. This means that an additional income of Php 1,470,000.00/yr will be earned by the farmers in a community with one extractor at Php 25/kg of malunggay. This is aside from the Php 2,076,169.20 income if the farmers adopt the zero waste processing technology for malunggay, which will produce by-products like juice, powder, and tea sold at Php 62/kg of malunggay. If the extractor is paid at about Php 2.00/kg in extracting the *Moringa*, it has a return of investment of 49.00% with a payback period of two years and one month. Thus, malunggay processing would create business and job opportunities for the various sector of the community.

The study recommends that the innovated extractor be downsized to suit the needed capacity of the microprocessors. Further, determination of the nutrient retention and loss during processing is warranted. Finally, commercialization of the machine may be done through proper promotion and marketing.

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References

Anwar, F., Latif, S., Ashraf, M., & Gilani, A.H. (2007). *Moringa oleifera*: A food plant with multiple medicinal uses. Phytotherapy Research, 21, 17–25.

Babu, S. (2000). Rural nutrition interventions with indigenous plant foods—A case study of vitamin A deficiency in Malawi. Biotechnology, Agronomy, Society, and Environment, 4(3), 169–179.

Barminas, J.T., Charles, M., & Emmanuel, D. (1998). Mineral composition of non-conventional leafy vegetables. Plant Foods for Human Nutrition, 53, 29–36.

Broin, M. (2006). The nutritional value of *Moringa oleifera* Lam. leaves: What can we learn from figures? MoringaNews: Moringa and Future Resource Plants. http://www.Moringanews.org/doc/GB/Posters/Broin_poster.pdf.

General, M. A., & Guerrero, J. J. G. (2017). Records of Fungal Endophytes from *Canarium ovatum* Engl.(Family Burseraceae) Leaves. Philippine Journal of Science, 146(1), 1-5.

Naseer, S., Hussain, S., Naeem, N., Pervaiz, M., & Rahman, M. (2018). The phytochemistry and medicinal value of *Psidium guajava* (guava). Clinical Phytoscience, 4(1), 1-8.

Owusu, D., Ellis, W. O., & Oduro, I. (2008). Nutritional potential of two leafy vegetables: *Moringa oleifera* and Ipomoea batatas leaves. Scientific Research and Essay 3(2), 57-60.

Palada, M. C. (2015, November). The moringa industry in the Philippines: status, challenges and opportunities. In I International Symposium on *Moringa* 1158 (pp. 447-454).

Price, M. L. (2007). The *Moringa* tree. ECHO technical note, 17391, 1-19.

Sandoval, M. A., & Jimeno, C. (2013). Effect of malunggay (*Moringa oleifera*) capsules on lipid and glucose levels. Acta Medica Philippina, 47(3), 22–27.