Design and Fabrication of Soil Sifting Machine for Value Added in The Black Ginger Herbal Production

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ABSTRACT

The soil sifting machine was designed and built to remove soil from harvested black ginger before processing or selling. The small and micro community enterprises are involved in the design and building procedure, including resolving the problems and improvements to the soil sifting machine. As a result, the soil sifting machine was fully functioning and fulfilled the needs of small and micro community enterprises. The machine consists of two main important parts, which are the power transmission and the sifting part. The test run was powered by a 1/4-horsepower motor, using 50 kilograms of black ginger each time at 16, 32, and 50 revolutions per minute. The result showed that the machine sifted the soil out of 750 kilograms of black ginger per hour at 16 revolutions per minute, which was its best performance. After sifting, the black ginger batch was not fractured, but there was a little bit of soil stuck between their rootstocks and some of their fibrous roots fell off. The soil sifting machine of the black ginger worked 18.75 times better than human work. The specific power consumption ratio was 1.27 baht per hour, resulting in a 90 percent efficiency and a 20-day payback period..

Keywords: Black ginger, Soil sifting machine, Value added

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Introduction

Black ginger is a traditional herb of the Hmong hill tribes in the mountainous areas of Phetchabun, Phitsanulok, and Loei provinces. Nowadays, black ginger is one of five healthy products chosen by the Ministry of Public Health as part of the development of a creative product model to create value for the Thai economy. [1] by commercial cultivation promoted by cooperating with universities and farmers from various areas such as Loei, Tak, Kanchanaburi, Phetchabun, and Udon Thani provinces and private sectors in order to export. [2] Black ginger can be processed by drying and extracting substances mostly for domestic consumption: 70% food and 30% medicine. Some of them were exported to Japan and China for drinking and food supplements, and up to 90% of them were pharmaceutical capsules. The research reports that black ginger truly enhances sexual performance. According to Thai medical textbooks, bolus was made of dried black ginger powder mixed with honey and molded, or pickled, liquor and pickled honey. At present, black ginger products are available in many types in the market, such as tea powder, capsules, potion, tablets, coffee, and black ginger wine, which are popular with high demand in the market. Black ginger is a short-lived plant with a rhizome the same as ginger, galingale, and Cassumunar ginger. The rhizome is a long, round, oval feature with nodes of similar size. The rhizome peel is light brown to dark brown and contains many important substances such as essential oils, flavonoids with flavones (5,7- dimethoxyflavone, 5,7,4'-trimethoxyflavone, 5,7,3', 4'-tetramethoxyflavone and 3,5,7,3', 4'-pentamethoxyflavone), antho-cyanins and phenolic compounds. The dark rhizomes contain more total phenolic and flavonoid content than lighter rhizomes, but the lighter rhizomes contain more essential oil.[4] Black ginger can be grown year round, but the proper time period is between March and May, and the harvest period is between November and February. The suitable soil for growing black ginger is sandy loam with subangular blockly, which is the kind of soil on the Khao Kho plateau in Phetchabun Province. [5]

Almost every household has grown black ginger in Khek Noi Subdistrict, Khao Kho District, Phetchabun Province, so the highland herbal micro community enterprise was established for the purpose of buying and distributing the fresh herbs and processed herbs. Black ginger is the top-buying and exporting herb. The average buying price is 100 baht per kilogram without soil removed. Then the micro community enterprise has to do the cleaning process by hiring 12–15 people per day. The wage is 300 baht per person per day. The cost of buying black ginger is contaminated with 5% of soil, and the total daily black ginger is 6 tons. According to the micro community enterprise expanse, labour wages and packing costs, including the loss from soil that is attached to black ginger rhizomes, lead to the loss of selling black ginger in some of the batches. However, using the water for the cleaning process instead of labor causes the rhizome or the black ginger root to rot or become moldy in the process. The average selling price of black ginger on the market is 130 baht per kilogram, and the average production capacity is 5.7 tons per day. [7]. As a result, the purpose of this research is to design and build a soil sifting machine for black ginger in order to reduce fatigue and labor costs associated with the soil removal

process, as well as to add value to the black ginger products of the highland herbal micro community enterprise in Khek Noi Subdistrict, Khao Kho District, Phetchabun Province. It will increase production rate, remove the soil from fresh black ginger during the buying process, reduce the loss of soil and resolve the problems from using water in the cleaning process.

Material and Methods

The methods of design and fabrication used in this research are as follows:

1. Study of the black ginger.

Study about the characteristics, soil for growing, and cleaning process of black ginger in the highland herbal micro community enterprise. First, talk to the community about the issues with removing soil from black ginger and the black ginger production process, and then interview the entrepreneurs. After that, get the farmers to dig up the black ginger rhizomes with sub angular blockly sandy loam attached and bring them to two cleaning methods. In the first method, laborers sift the black ginger in a basket, which is a time-consuming task. The second one is to spray the water to wash the black ginger, which is not an effective way because the moisture will cause the black ginger to rot.

2. Studied the theory and related

Gathering the information and studying related research in order to design and fabricate the soil sifting machine for black ginger and also study the concept of a revolving screen or trommel [6-7].

Figure 1 Illustration of a Revolving Screen or Trommel.

3. Design and Fabrication of Soil sifter

In order to design and build a clay glider, community discussion was needed, as well as gathering information for the design of the soil glider. Soil gliders have to inform the community enterprise about their safety. Designing and building a clay glider from studying the research and related theory consists of the following steps and sub-details.

Designing a concept, engineering drawings, building a machine, and conducting experiments are all part of the process.

The test will use a lot of the black ginger rhizomes with soil attached from the plot, an amount of 50 kilogram each time. The sieve spacing is about 9 millimeters . to prevent the black ginger rhizomes from cracking or falling off. The design of a soil glider consists of two main parts, which are the power transmission system and the soil gliding system. The power transmission system consists of a 1/4

horsepower geared motor, a 12 inch pulley, and 3 of 5 inch pulleys [8–9]. The glide system consists of the soil glider structure shown in Figure 2. Number 1) is the machine structure, 580 millimeters in width, 1860 millimeters in length, and 650 millimeters in height, made of a 25 millimeter x 25 millimeter x 3 millimeter steel box. Number 2) is a sloped tray. Waste soil beyond this sloping surface slides off. made of St. 37 sheet steel, 3 millimeters thick. Number 3) is Hopper, a bucket of black ginger, made of St. 37 sheet steel, 530 millimeter of width x 732 millimeter of height, 3 millimeter thickness. Number 4) is the black ginger tray used to store the black ginger before entering the hopper. 25 millimeters wide x 1110 millimeters tall x 3 millimeters thick, made of St. 37 sheet steel. Number 5) is the awning sheet to prevent the soil from splashing out. made of St. 37 sheet steel, 25 millimeters wide x 1110 millimeters tall, 3 millimeters thick. Number 6) is a rotating grate and a screw guide made of steel bars. It has a diameter of 420 millimeters, a length of 1560 millimeters, and two round bars of 10 millimeters and 5 millimeters, welded alternately along the length of the sieve with an 8-millimeter diameter on each bar. Number 7) is a tray that supports black ginger. For black ginger, after the soil has been removed, made of St.37 sheet steel, 3 millimeters thick. Number 8) is the power shaft used to transmission power to the rotating screen.

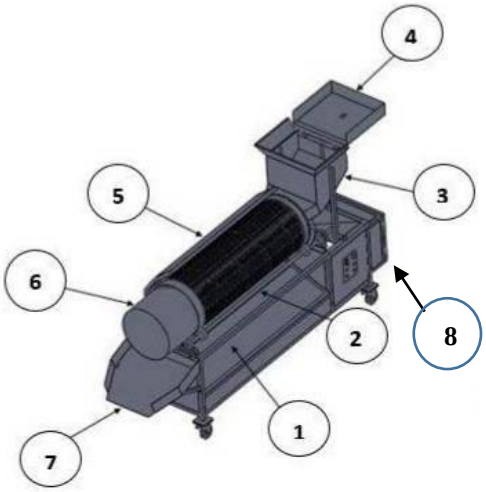

Figure 2 Illustration of Soil sifting machine structure.

Figure 3 Illustration of Soil sifting machine.

4. Soil sifting machine performance test

This experiment used black ginger rhizomes with soil attached from the farmers in Khek Noi sub-district, Khao Kho district, Phetchabun province.[12] The 50 kilograms of black ginger were used each time in this experiment at rotational speeds of 16 revolutions per minute, 32 revolutions per minute, and 50 revolutions per minute. (Figure 3) Conducting each experiment to calculate the specific power consumption of the various speeds shown in equations (1) and (2);

$$P = IE \quad (1)$$

$$\text{Electricity cost (baht)} = P \times \text{Electricity rate per unit (baht)} \quad (2)$$

Thus: P = is Electric power
I = is Electric current
E = is Voltage

Results

The results from sifting the black ginger for one hour show that the black ginger quality increased with higher rotational speeds. The soil sifting machine can process black ginger with soil at 750 kilogram per hour, 875 kilogram per hour, and 1,125 kilogram per hour at 16 revolutions per minute, 32 revolutions per minute, and 50 revolutions per minute, respectively. After sifting, the soil lost from black ginger was 37.5 kilokrạm, 25.7 kilogrạm and 12.7 kilogrạm, respectively, and the specific energy consumption was 1.27 baht per hour, as shown in Table 1.

Table 1 Soil sifting test for 50 kilograms of black ginger at 16, 32 and 50 revolutions per minute.

Rotational speed (revolutions per minute)	Black ginger (Kilogram)			Sifting time (min.)
	before	after	Lost weight of soil	
16	50	47.50	2.50	240
32	50	48.50	1.50	210
50	50	48.67	1.33	160

The target group to assess their satisfaction there are 10 people working in the community with 11 years of experience and 5 experts who have experience in checking the quality of black ginger produce. According to the specified criteria, After having tested the machine's performance, a satisfaction assessment was carried out for the herbal community enterprises relating to the usability of the machine. It was conducted in three parts. In the satisfaction assessment, the first aspect is the design, with an average satisfaction value of 4.65 and a standard deviation of 0.50 in the criteria for the highest

satisfaction level. Regarding the second machine performance, the average satisfaction value is 4.77 and the standard deviation is 0.38 in the criteria for the satisfaction level. Aspect three is about machine attribution. The average satisfaction value is 4.95 and the standard deviation is 0.16 in the criteria for the satisfaction level. The average overall satisfaction in all 3 aspects is 4.79, with a standard deviation of 0.35 in the criteria for the satisfaction level. [10] At 16 revolutions per minute, the cleanliness of the black ginger from the herbal community enterprises is 90 percent. The characteristics of the black ginger after sifting are that it has a little bit of soil stuck in the gap of the rhizome. There was no fracture to the black ginger, however some fibrous root was lost, as shown in Table 2. This is the result of the experiment that gave the best quality of black ginger. The weight of the soil, which was loosened as much as possible, caused the least amount of damage.

Table 2 Cleanliness of the black ginger at rotational speeds of 16, 32 and 50 revolutions per minute.

rotational speed (revolutions per minute)	characteristics of the black ginger		Percentage of cleanliness (percent)	Characteristics of the black ginger rhizome after sifting.
	Before sifting	after sifting		
16			90	Most efficient, lest amount of soil remained with also the least amount of root damage
32			75	More soil remained and more root damage was caused revolutions per minute
50			73.33	At this speed more soil remained on the black ginger than at 16 or 50 revolutions per minute also it suffered the most root damage

The soil sifting machine's performance was tested with an electricity output of 0.25 kilowatt per hour. The soil sifting machine works with 750 kilogram of black ginger per hour for 6 hours per day for 120 days per year. The cost of the work and the payback period of the soil sifting machine can be calculated as shown in Table 3. From the analysis of the economic cost, the soil sifting machine has a payback period of 20 days. The comparison between soil sifting and manual labor can be seen in Table 3. The soil sifting machine was able to sift 750 kilokram per hour at a cost of 0.06 baht per kilokram. The comparison between the soil sifting machine and the farm worker is 90 percent and 95 percent, respectively, as shown in Table 4. However, the efficiency will decrease as a result of fatigue. As a result, if a worker sifts soil from black ginger for an extended period of time, the worker will become stagnant, and the amount of soil sifted from black ginger by the worker will decrease in efficiency. [11]

Table 3 Economics: the cost of a soil sifting machine

Fixed cost		Variable cost	
Soil sifting machine price	30,000 baht	Average maintenance cost is approximately 10 baht per day, working 120 days per year.	1,200 Baht/year
Value of the remains for the sifting machine at the end of the 5th year it has a residual value of 10 percent of machine price S = (10/100) x 30,000	3,000 baht	Average electricity cost 0.25 kW/h Electricity price 3.5 baht per unit in 1 year, working 120 days, 6 hours a day (= 0.25x3.5x120x6)	630 baht/year
Depreciation (DP) = (P-S)/L = (30,000-3,000)/5	5,400 baht/year	Labour wages 300 baht per day for 1 person to work 120 days (Working during the harvest of black ginger)	36,000 baht/years
Interest on investment, I=[(P+S)/2) x (i/100)] The interest rate is 10 percent per year. [(30,000+3,000)/2]x(10/100)	1,650 baht/year		
The costs to operate the machine (baht per kilokram) for one year working 720 hours, Working capacity 750 kilokram per hour = 30,630/(720x750)		0.06 baht per kilokram	
Labour cost to sift black ginger manually, 1 baht per kilokram, work 50 kilokram per hour.		50 baht/h	
Time working		720 h/year	
interest		1,650 baht/year	
Variable cost		30,630 baht	
Total cost 30,630 + 1,650		32,280 baht	
Benefits 720 x 750		540,000 baht/year	
Net benefit 540,000 - 30,630		509,370 baht/year	
Payback period (30,000/540,000) x 12		0.67 month or 20 days	

Table 4 Comparison performance between the soil sifting machine and manual labour

Comparison	Soil sifting machine	Labour
1. Work ability (kilogram per hour)	750	40
2. The cost of work (baht per kilogram)	0.06	1
3. The cleanliness of black ginger (percent)	90	95

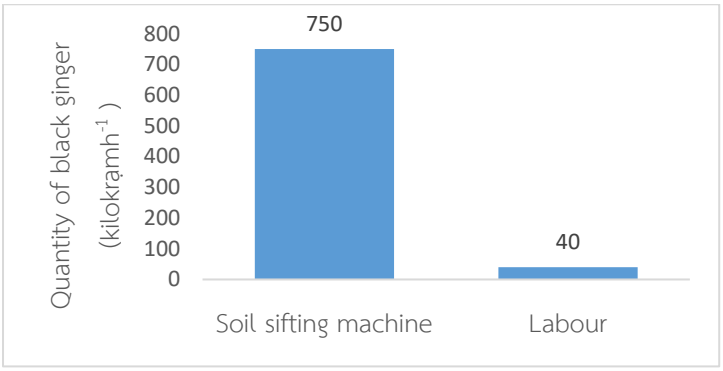

Figure 4 Illustration of comparison performance between the soil sifting machine and manual labour

The comparison between the soil sifting machine and manual labour is shown in Figure 4. The soil sifting machine was able to process 750 kilograms of black ginger with soil per hour. The best result was at 16 revolutions per minute. Black ginger with soil was sifted using manual labor, resulting in 40 kilogram per hour being processed, but the percentage of cleanliness of the worker is 95 percent, but the machine is 90 percent. Therefore, the soil sifted by the machine is 18.75 times more efficient than manual labour.

Discussion and Conclusion

After sifting out the soil from the black ginger, you will have 750, 875, and 1,125 kilograms per hour of soil at 16, 32, and 50 revolutions per minute, respectively. The result showed that 37.5, 25.7, and 12.7 kilograms of weight, respectively, were removed from the black ginger, with a specific energy consumption of 1.27 baht per hour. As shown in Table 4, the percentage satisfaction and cleanliness of the black ginger from the herbal community unity enterprises were 90 percent at 16 revolutions per minute less than from labor. The characteristics of the black ginger after sifting were some soil stuck on the rhizome, no fracture, and some small fibrous roots fell off. The soil sifting machine was able to work 18.75 times better than manual labor, and the payback period was 20 days. After using the soil sifting machine in the production process, the costs were reduced and the production rate was increased. Because of the machine design and fabrication in association with the herbal community unity

enterprises, the cleaning and maintenance of the soil sifting machine was easy for them. Leading to reduced or replacements for workers for a long period of time and tiring jobs.

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