Asia-Pacific Journal of Science and Technology: Volume: 24. Issue: 04. Article ID.: APST-24-04-01. Research Article

APST

Asia-Pacific Journal of Science and Technology

https://www.tci-thaijo.org/index.php/APST/index

Published by the Research and Technology Transfer Affairs Division,
Khon Kaen University, Thailand

# Innovation development of durian stick processing machine for transferring knowledge to foundation community

Charnchai Phontri[1,*] and Ruephuwan Chantrasa[1]

[1]Department of Industrial Engineering, Faculty of Engineering, Burapha University, Chonburi, Thailand
[*]Corresponding author: charncha@eng.buu.ac.th

Received 24 March 2017
Revised 9 August 2019
Accepted 13 August 2019

**Abstract**

Durian is one of the most famous tropical fruits of Thailand. The consumption of durian can be in the form of both fresh durian and processed durian, such as chips, cakes, and crunches. This research aims to innovatively develop the durian stick processing machine. The machine is intended to perform efficiency and effectively according to the users' needs before transferring the knowledge to the foundation community. The research applied Quality Function Deployment (QFD) in order to design and develop the conceptual model of the machine that responds to the true needs of the agricultural community of Khao-bai-sri, Chanthaburi Province. The research began by studying and collecting data of the fried durian stick processes. A survey of the agriculturist needs of the durian stick processing machine was then performed. The needs were analyzed by applying QFD to establish the technical specifications of the machine. The research then generated 4 alternative conceptual models and selected the most appropriate one. A prototype of the machine was constructed, tested and refined in order to verify its operations. The durian stick processing machine developed in this research was used in actual production in which the agriculturists were satisfied with the machine usage. Finally, the knowledge generated in this research was transferred to the foundation community.

**Keywords:** Innovation, Foundation community, Durian stick, Machine design, Quality function deployment

## 1. Introduction

At present, in Eastern Thailand, fruit is a major component of agriculture. Chanthaburi province is well-known for growing various famous tropical fruits such as rambutan, mangosteen, zalacca, langsat and durian. The durian, also known as the "king of fruit", is a domestically and internationally popular fruit [1]. According to the Office of Agricultural Economics, in 2017, the production volume of durian in Thailand was 634,811 ton. The fresh durian consumed accounted for 121,090 ton domestically, whereas the export volume of durian was 513,883 ton [2]. In terms of durian consumption, people usually like to eat fresh durian. However, processed durian in forms such as durian chips, durian cakes, and durian crunches are also popular among Thais and foreigners [3-4]. Currently, deep-fried durians are produced in 2 forms; durian chips and durian sticks. The Durian chip is a well-known durian product and can be produced widely over the area in Chanthaburi [5]. Khao Bai Sri is a long-established agricultural community in Chanthaburi. Most of its residents grow fruit trees such as durian, rambutan and mangosteens. Due to the excess supply of durian, the community produces deep-fried durian which has become popular. This community had an idea to produce other shapes of the processed durian, which led to the creation of durian sticks. This product, afterwards, created more value to the durian product and won the outstanding product award last year. However, the processing of deep-fried durian sticks encountered problems

in productivity and quality. All processes are manually operated, and the degree of labor needed means they cannot produce enough products to supply the market.

According to this problem, the Khao-bai-sri agricultural community in the Chanthaburi province requires effective equipment to produce the deep-fried durian stick. This research aimed to apply design techniques to develop an innovative machine to produce deep-fried durian stick in response to the community's need. The research also aimed to evaluate the effectiveness of the developed machine to operate as the user intended. The machine is powered by electro-pneumatic systems to increase the productivity and quality of the operation processes. The knowledge acquired in the research is then transferred to the foundation community to carry on through folk wisdom, creating a more sustainable community.

## 2. Materials and methods

### *2.1 Study and collect relevant data*

This step was to study and collect data related to the durian processing, such as deep-fried durian shape and size, tools and equipment used for agricultural processes.

### *2.2 Survey and collect community needs*

In this step, the questionnaire used to collect the needs of the community corresponding to the stick durian processing was designed. Customer needs obtained from the survey were analyzed using quality function deployment (QFD) [6] to identify the technical characteristics of the durian cutting machine which would be the initial step to further machine design.

### *2.3 Design the prototype of the durian cutting machine*

The technical characteristics of the machine derived from QFD were used as the design data for the durian stick processing machine. The design processes included tentative product design, brainstorming for the suitable design, machine detail design, and part design.

### *2.4 Building of the durian cutting machine*

This step employed the detail designs to plan and construct the durian stick processing machine.

### *2.5 Operational test of the durian cutting machine and correction*

After the prototype of the durian cutting machine was developed, operations of the machine--machine efficiency, machine capability, quality and safety--were tested to see whether they worked as intended. The testing was performed both in the laboratory and in the site at Khao-bai-sri community. The problems that occurred in the test would be corrected and improved.

### *2.6 Training the machine operations to the community*

After the durian cutting machine was developed completely, the community training for the usage was conducted in order to transfer knowledge to the community.

## 3. Results

### *3.1 Deep-fried durian process*

The deep-fried durian processes included 7 steps as shown in Figure 1. The process started with the preparation of durian flesh at 80% maturity. Following the 7 steps of the processes, the final process was packing the fried durian sticks into the plastic bags to be ready to sell to customers.

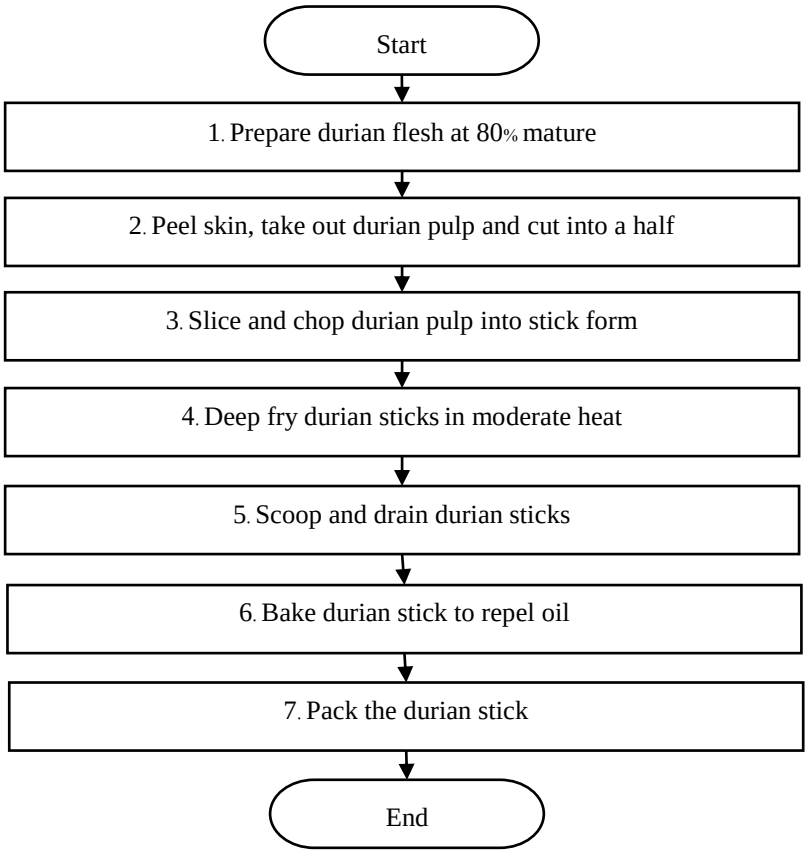


**Figure 1** Deep-fried durian process.

*3.2 Survey the needs of the community*

Needs of the agricultural community of the durian stick processing machine were surveyed via interview with open-ended questionnaire. The needs were reviewed and translated into 17 customer needs, which then were grouped to 5 primary needs as shown in Table 1. QFD was applied to deploy the customer needs into the technical requirement of the durian stick processing machine as shown in the house of quality as in Figure 2.

**Table 1** Customer needs of the durian stick processing machine.

| No. | Primary need | Secondary need |
|---|---|---|
| 1 | Ease of assembly and installation | Ease of parts assembly |
| 2 | | Convenient relocation |
| 3 | Suitable shape and size | Suitable size |
| 4 | | Lightweight |
| 5 | | Stability of the machine |
| 6 | Appropriateness of function and usage | Safety operation |
| 7 | | Compatible with household electrical supply |
| 8 | | Ease of operations |
| 9 | | Minimal durian scrap |
| 10 | | Durable cutter |
| 11 | Efficiency of machine operations | Capable of continuous machine operation |
| 12 | | Ease of feeding durian flesh |
| 13 | | Easily release durian stick |
| 14 | | Accurate durian stick size |
| 15 | | High throughput |
| 16 | | Low machine vibration |
| 17 | Machine cost | Reasonable cost |

Results derived from the QFD showed that the significant technical requirements of the durian stick processing machine were processing rate, consecutive machine operation time, durian releasing rate, machine size, characteristic of feed in slot, and the cross-sectional area of durian stick with the priority score of 0.109, 0.090, 0.079, 0.077, 0.064, and 0.060, respectively. These requirements were then used as a guideline for the conceptual design of the durian stick machine.

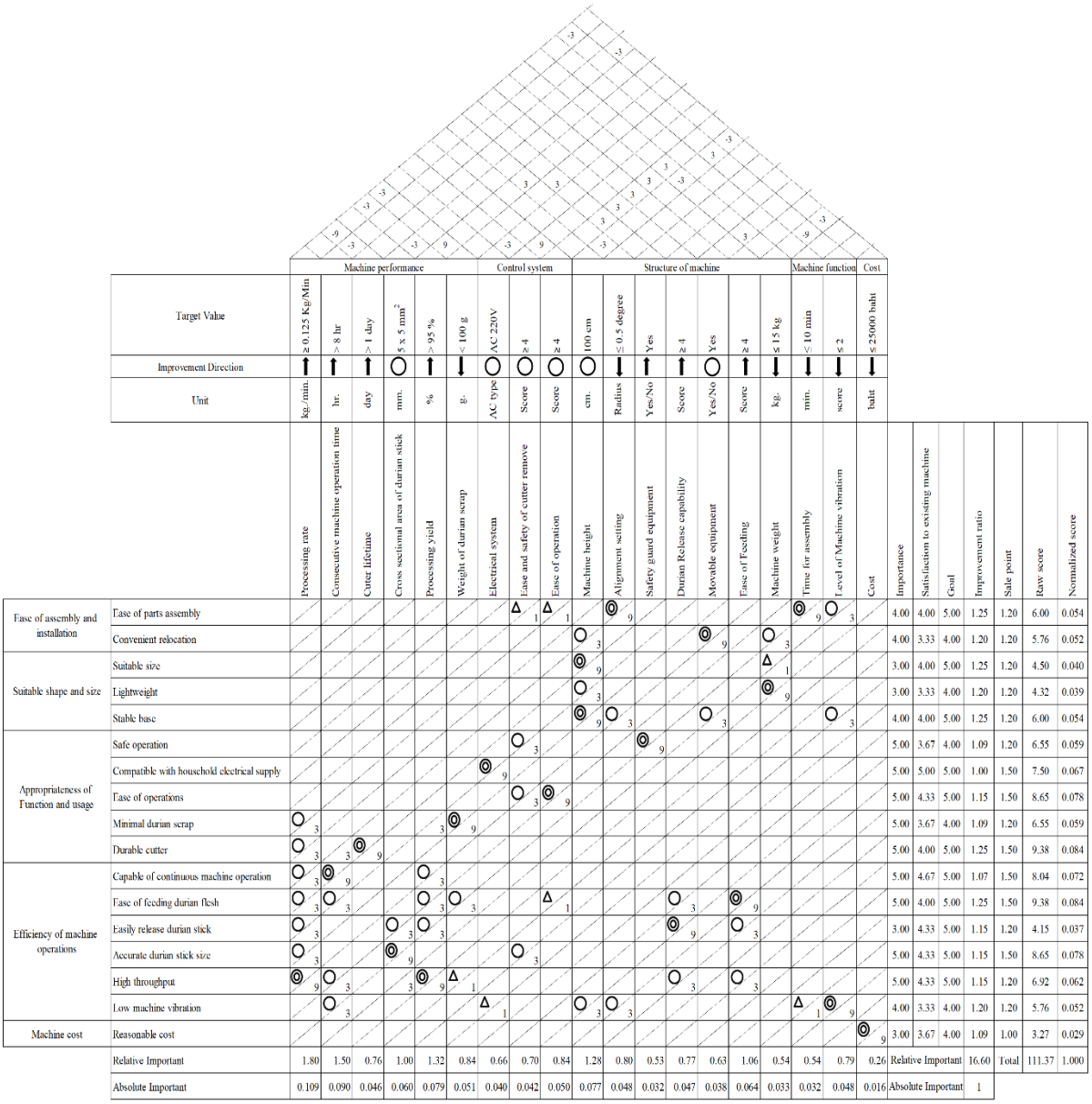


**Figure 2** House of quality of durian stick processing machine.

### *3.3 Conceptual design of the durian stick processing machine*

To develop the conceptual design of the durian stick processing machine, the machine was decomposed into 3 subsystems including; cutter moving system, cutter type, and feeder type. These subsystems were analyzed for their alternative solutions that would be applied to the machine. For example, the alternative solutions for the cutter moving machine were pneumatic system and electrical motor system (Figure 3). Merging these solutions, there were 16 possible combinations (2×4×2). After considering these combinations thoroughly, 4 possible machine concepts were selected (Table 2). The drawing of each machine concept was then generated as shown in Figure 4.

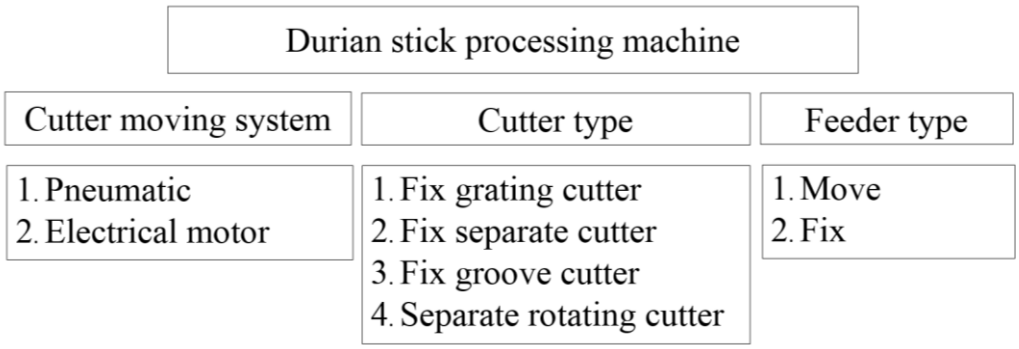


**Figure 3** Subsystems and solutions of the durian stick processing machine.

**Table 2** Alternative concepts for the durian stick processing machine.

| Concept | Cutter moving system | Cutter type | Feeder type |
|---|---|---|---|
| 1 | Pneumatic | Fix grating cutter | Fix |
| 2 | Pneumatic | Fix separate cutter | Move |
| 3 | Pneumatic | Fix groove cutter | Fix |
| 4 | Electrical motor | Separate rotating cutter | Fix |

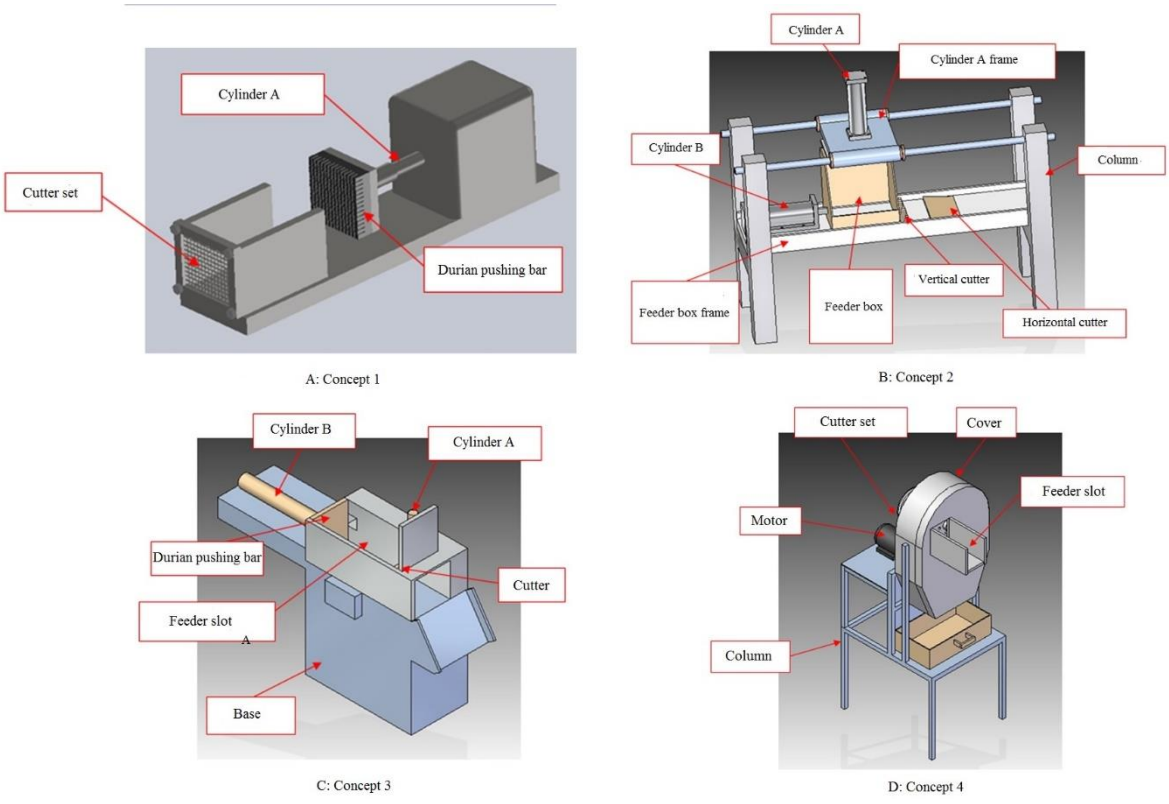


**Figure 4** Concept design of the durian stick processing machine.

The 4 alternative concepts were evaluated using customer needs obtained from the QFD as the evaluation criterion. The evaluation was performed by considering the strength and weakness of each concept using a 5-point Likert scale. The total score of the concept was calculated by the summation of the multiplication of criteria weight and the score [7]. The result of the evaluation showed that Concept 2 obtained the highest score at 3.53 (Table 3). Hence, Concept 2 was selected and further used for the detail design and construction of the prototype model.

**Table 3** Evaluation of alternative concepts.

| No. | Criteria | Target value | Weight | Rate score of concepts | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 |
| 1 | Processing rate | ≥ 0.125 kg/min | 0.2 | 3 | 3 | 2 | 3 |
| 2 | Consecutive machine operation time | ≥ 8 h | 0.18 | 2 | 3 | 2 | 3 |
| 3 | Processing yield | ≥ 95% | 0.16 | 4 | 4 | 4 | 2 |
| 4 | Ease of operation | ≥ 4 score | 0.10 | 3 | 4 | 3 | 3 |
| 5 | Alignment setting | ≤ 0.5 degree | 0.10 | 3 | 4 | 3 | 3 |
| 6 | Durian release capability | ≥ 4 score | 0.09 | 2 | 4 | 2 | 3 |
| 7 | Cutter life time | ≥ 1 d | 0.09 | 2 | 3 | 3 | 3 |
| 8 | Ease and safety of cutter remove | ≥ 4 score | 0.08 | 3 | 4 | 2 | 3 |
| Total | | | 1.00 | 2.80 | 3.53 | 2.61 | 2.84 |

The selected concept was used in the detail design of 2 main parts; 1) structure frame and 2) operation control system. The structure frame of the machine used material that has high strength, durability and safety. The dimension of the machine structure was 450 mm in width, 880 mm in length and 780 mm in height.

The cutting systems include 2 cutter sets--vertical and horizontal cutters which were fixed at the positions. The vertical cutter set comprised of many cutters. The space between the cutters was 5 mm. The horizontal cutter is a single cutter of 130 mm. The pneumatic system was applied to feed durian pulp into the cutter. Two cylinders were used, one to hold the durian, the other one to feed durian flesh to the cutter. The control system was designed to be used with 220-volt AC. The circuit for the pneumatic system was 24-volt DC. The transformer was installed in the control box to transform AC to DC. The air pressure was set at 6 bar. The step diagram of machine operations is shown in Figure 5. The electro-pneumatic control circuit is shown in Figure 6.

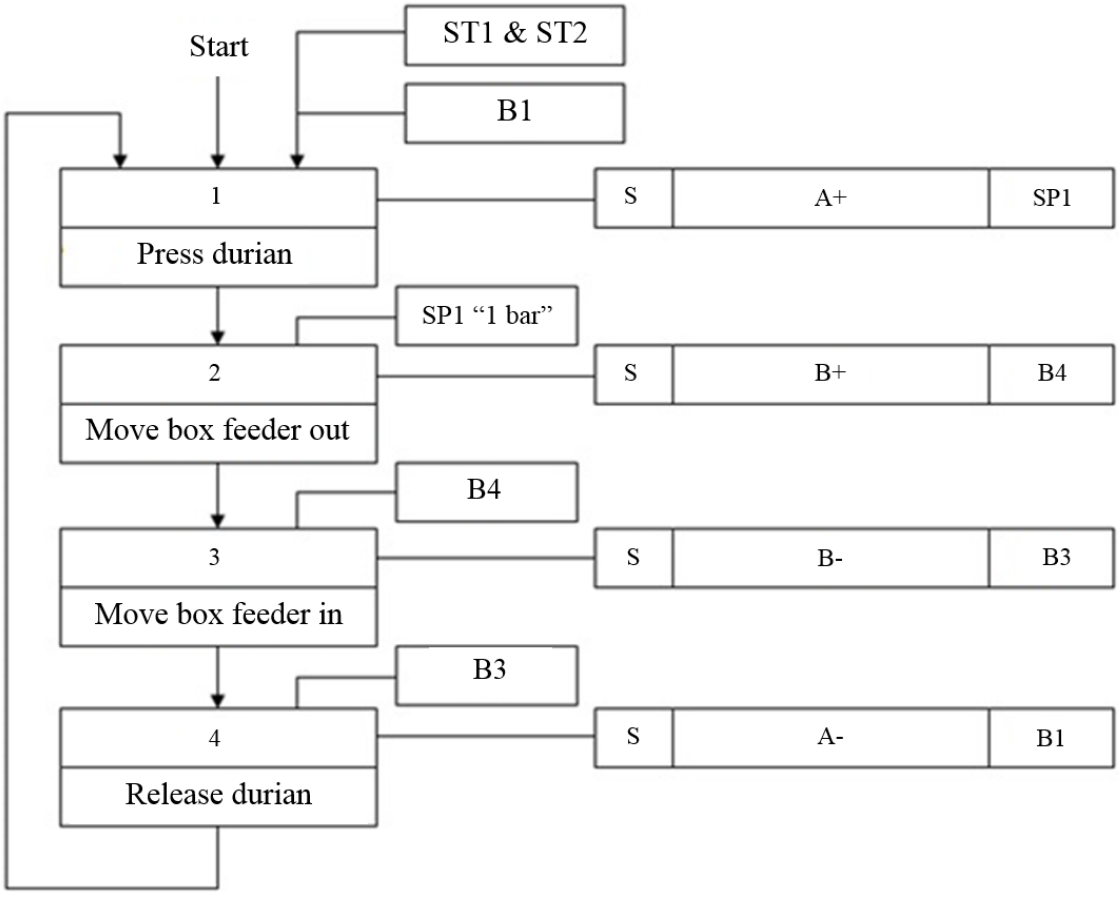


**Figure 5** Step diagram of machine operation.

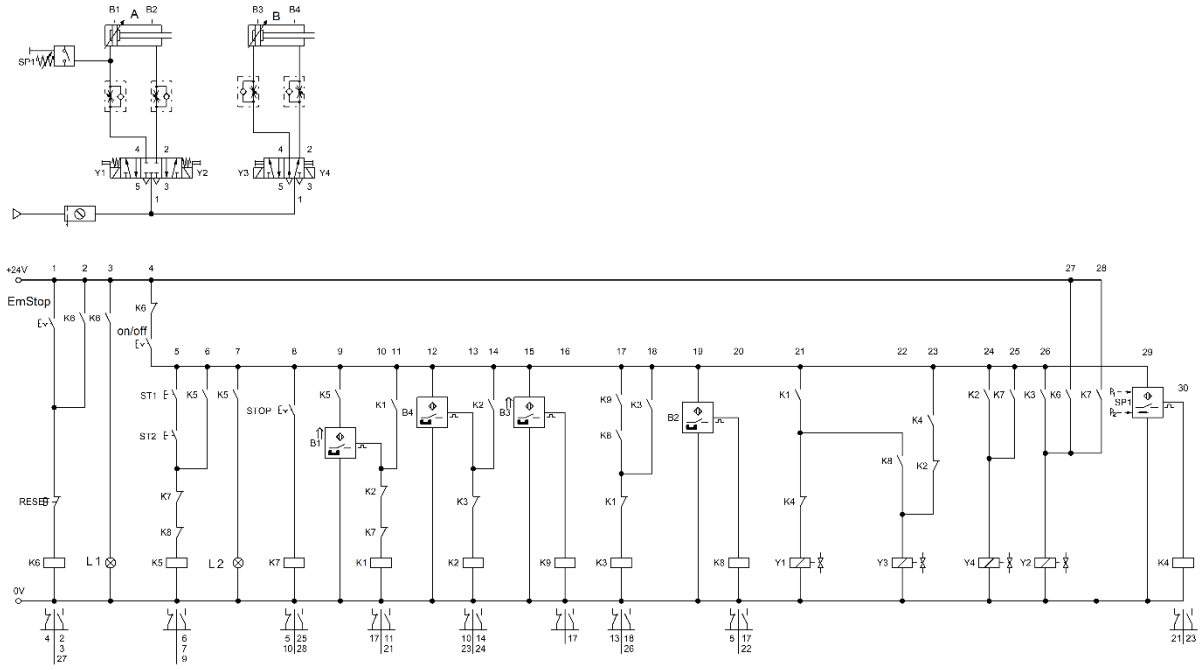


**Figure 6** Electro-pneumatic control circuit.

*3.4 Building of the durian stick processing machine*

*3.4.1 Structure frame*

Parts and components of the structure frame were created as informed by the design. They were then assembled to be the machine structure frame as shown in Figure 7.

**Figure 7** Structure frame of the durian stick processing machine.

*3.4.2 Installation of control units*

The control units of the machine including electrical control system and pneumatic control system were installed in the machine. These systems were tested to show whether they worked as the design suggested. The complete ready-to-work durian stick processing machine is shown in Figure 8.

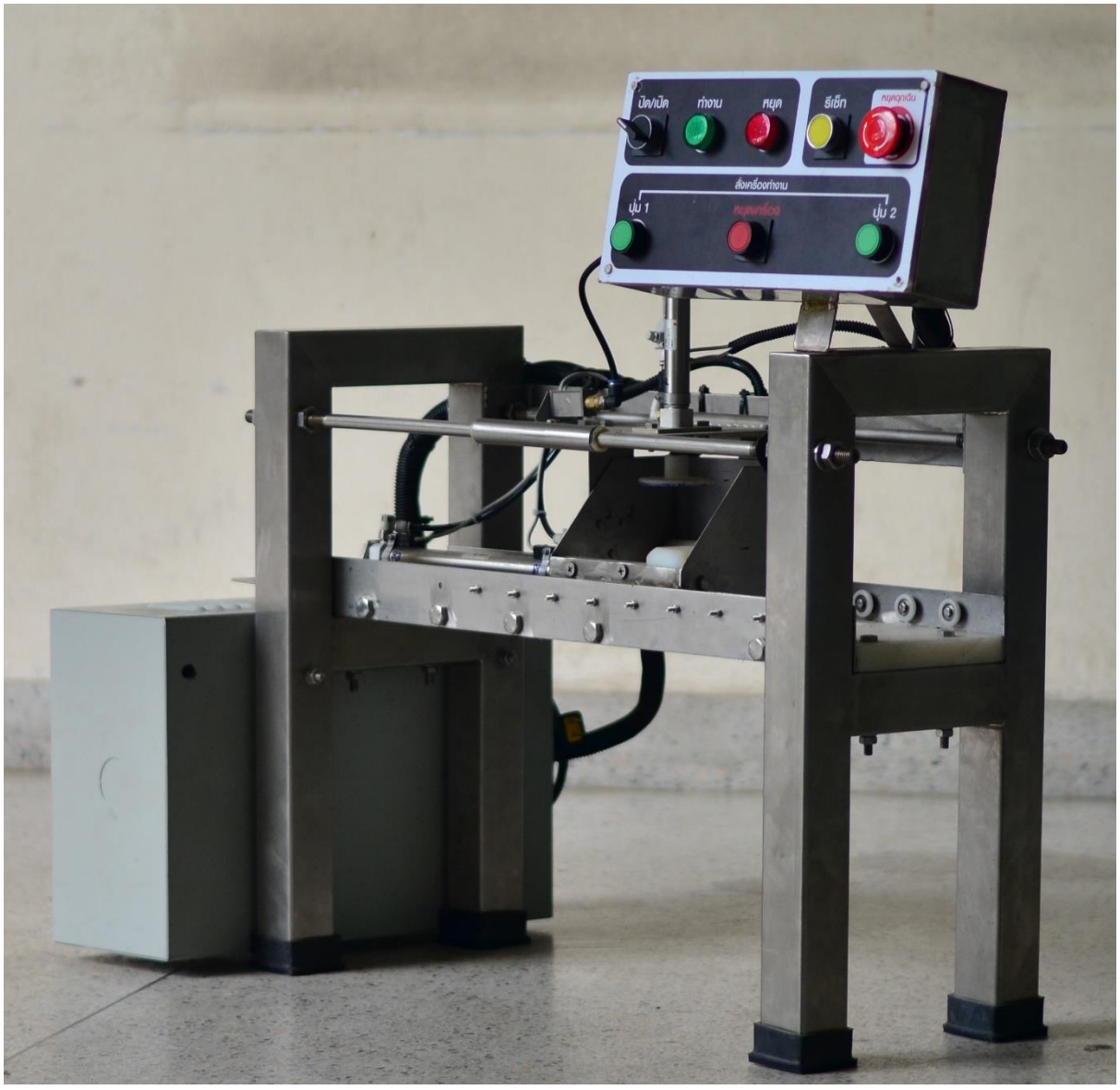


**Figure 8** The ready-to-work durian stick processing machine.

*3.5 Operation testing of the durian stick processing*

The operation of the machine was tested for the processing rate and the cross-sectioning of the durian stick. The fresh durian pulp before being processed by the machine is shown in Figure 9 (A) and the durian stick processed by the machine is shown in Figure 9 (B). The results of the test are shown in Table 4. Compared to the manual process before the improvement which had the processing rate at 0.125 kg/min., the developed machine increased the processing rate 176%. In addition, the cross section of durian sticks produced by developed machine was more accurate than the manual process. Moreover, the cross section of durian stick processed by the developed machine is acceptable to the target dimension at $5\times5$ mm$^2$

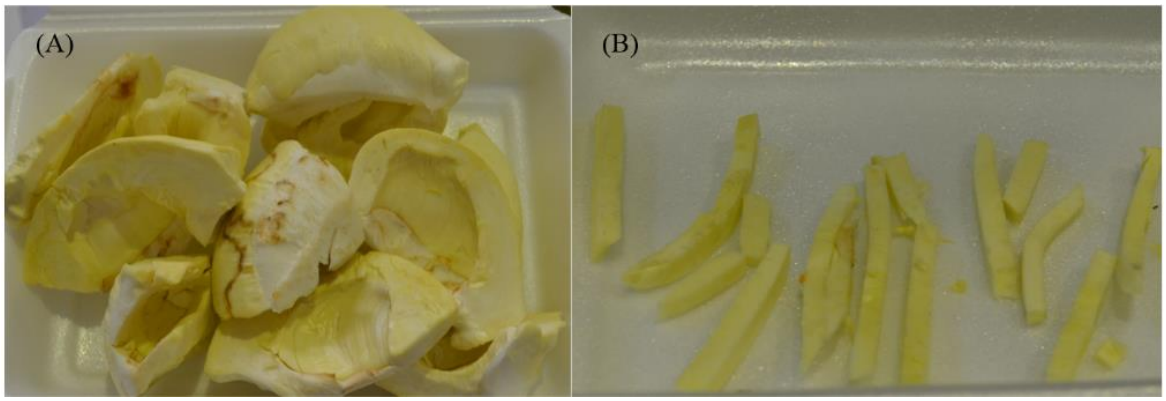


**Figure 9** Durian product (A) fresh durian pulp and (B) durian stick cut by the machine.

**Table 4** Results of the operational test.

| Number | Test item | Result |
|---|---|---|
| 1 | Average processing rate | 0.345 kg/min |
| 2 | Average cross section of durian stick | 5.04 × 4.92 $mm^2$ |

*3.6 Training the machine operations to the community*

In the final step, the durian stick processing machine was used in the real environment at the Khao-bai-sri agricultural community (Figure 10). This step aimed for transferring the knowledge obtained from this research to the foundation community. The community was trained to use the machine step-by step along with the operation manual handbook. After the community used the machine for a short period of time, they evaluated its performance. The average score of satisfaction was 3.4 out of 5.

**Figure 10** Training of the machine operations at the community.

## 4. Conclusion

In this research, the durian stick processing machine was improved according to the Khao-bai-sri agricultural community's needs. The real needs of the community were collected and used for the conceptual design of the machine using Quality Function Deployment. The operation of the machine was controlled by using electro-pneumatic systems. The durian stick processing machine was able to operate effectively in the real environment and can produce durian sticks at a higher rate and with higher accuracy of stick size and shape. It is an innovative machine that responds the desire of the community and will create strength and sustainability for the community in the future.

## 5. Acknowledgements

The authors gratefully acknowledge the financial supports from the Research and Innovation for transferring technology to rural community project 2012 by Higher Education Development Network (East), Office of the Higher Education Commission.

## 6. References

[1] Grakei M, Seedang V. Crispy fried durian: international Thai snack [Internet]. 2110 [cited 2017 March 20]. Available from: http://info.matichon.co.th/techno/techno.php?srctag=05094010153&srcday=&search=n

[2] Gatesumpao P, editors. Agricultural economics by products year 2017. Nonthaburi: 21 Century Co., Ltd.; 2017. Agricultural Statistical Document No. 402. Office of Agricultural Economics, Ministry of Agriculture and Cooperatives.

[3] Grodganggan S. Designing and development of durian packaging in Cho-airond District, Narathiwat Province. Princess of Naradhiwas University Journal 2012; 7(2): 147-156.

[4] Wisaratanon P, Linpitatean P, Pisalwatchrin A. Processing of durain french fried-type product. Postharvest and processing research and development Division; 2006.

[5] Phontri C, Chantrasa R. An application of quality function deployment in designing and development of conceptual design for the durian shearing machine. In: Ketsarapong S, editors. The Industrial Engineering Network Conference 2012: Proceedings of the Industrial Engineering Network Conference; 2012 Oct 17-19; Phetchaburi, Thailand. Bangkok; 2012. p.1688-1693.

[6] Cohen L. Quality function deployment: how to make QFD work for you. Massachusetts: Addison-Wesley; 1995.

[7] Ulrich KT, Eppinger SD. Product design and development. 4th ed. New York: McGraw-Hill; 2012.