Development of A Semi-Auto Tea Packer Prototype for Agricultural SME in Thailand and Indonesia

Krit Lertlam[1], Sutiwas Duangjum[1], Denny Purnomo[2] and Chonlatee Photong[1*]

[1] Solar Energy and Energy Resources Research Unit, Faculty of Engineering, Mahasarakham University, Kham Riang, Kantarawichai, Maha Sarakham, 44150, Thailand

[2] Perum. Puri Langen Estate Blok F No. 3. Desa Kutasari, Kecamatan Baturraden, Kabupaten Banyumas, Kota Purwokerto. Kode pos 53151. Hp. 085713983983, Indonesia

Krit.ler@msu.ac.th, sutiwasd@gmail.com, dennypurnomo261183@gmail.com, and chonlatee.p@msu.ac.th*

Abstract. *This paper presents the study, design and construction of a semi-auto tea packer. The semi-auto tea packer prototype consists of 5 parts. The first part is a rotating part that will rotate when a sensor detects the tea of 2 g that falls down through the hole to the provided container. The second part is a weighting part that functions to control weight of tea to always be 2 g. The third part is a base that supports all the parts and weight of the tea packer. The fourth part is a control box that controls operation of the tea packer including: electronic circuits, sensors and power supply. The fifth part is a blender that helps to dispose the tea not to rush to fall down into the hole. The experimental results obtained from the tea packer prototype compared to one from the human showed that packing tea by a human could produce only 3-5 bag/min while using the designed tea packer could produce more with capability of 8-10 bag/min. This machine would help in enhancing SME activities with similar profile for both Thailand and Indonesia.*

Received by	14 September 2020
Revised by	2 November 2020
Accepted by	12 December 2020

Keywords:

Tea packer, motor control, industrial electronics, electronic applications, SME

1. Introduction

Besides water, tea is the most favorite beverage in the world; i.e., more than 1.39 billion people in China [1] and 159 million people in USA consume tea [2]. This is because of the fact that tea can boost exercise endurance, the catechins (antioxidants) in tea can help body to burn fat [3]-[5]. The antioxidants in tea can reduce the risk of heart attack, Parkinson's disease, diabetes, artery disease, stroke, and protect against cardiovascular and degenerative diseases, as well as, a boatload of cancers, including breast, colon, colorectal, skin, lung, esophagus, stomach, small intestine, pancreas, liver, ovarian, prostate and oral cancers. Tea also helps fighting free radicals with high oxygen radical absorbance capacity (ORAC) [6], hydrating to the body such as caffeine and protecting from ultraviolet rays. In additional, tea can help diabetics and improve bone mineral density and strength [7].

Tea sold in the marketplaces could be found in many forms of packaging but having the same purpose to keep longer the taste and smell while avoid deformation of substances inside the tea [8]. One of the most common ways is to use the tea bags [9]. Using tea bags for containing the tea provides convenience in usage with short time of making tea, suitable amount of tea needed per cup, and ease to dispose of simply remove from the tea cup with a teaspoon and place into the bin [9]-[11].

There are several types of machines (tea packers) and technologies used for putting tea into the tea bags [12]-[13]. However, most current tea packers are designed for large manufacturing, which have relatively high investment cost (+15,000$USD), require large installation area and consume high power for their operation. This causes difficulty for most small-medium enterprises (SMEs) or local farmers to use such the machines. In fact, most SMEs and local farmers in Thailand package the tea bags by using human labors. This leads to very low capability of producing tea bags (3-5 bag/min) [14].

Not only in Thailand, buy and sell transactions on agricultural and tea products are also ingrained in the Indonesian economy. Trading activities are the largest source of income. At present, the presence of SME that are active in building the economy can be said to be successful because based on data from the Indonesian Ministry of Cooperatives and SME it reports that in terms of number of units, SME have a share of around 99.99% (62.9 million units) of the total business actors in Indonesia (2017), and at least it has helped absorb about 97% of the national workforce. This SME is a crucial point that has a very large contribution to the country's economy. The general picture of the structure of SME in Indonesia today is that 98% of micro enterprises and the rest are small or medium enterprises that previously went from micro to graduate. In Indonesia alone, this SME is protected and has an umbrella of law such as the Presidential Decree No. 19/1998 and several other regulations. At this time, many SME businesses are starting to grow both on a household and large scale, including business related to culinary, fashion, agricultural, electronics, furniture, and services [15].

Technology has a very important role in advancing SME in Indonesia. Technologies that have an important role in advancing SME include marketing technology through digital marketing, business management technology and also production technology that applies appropriate technology in the SME production process. Production technology has a big enough role for SME to be able to compete with other SME and large companies. One of the roles of production technology for SME is to increase production capacity. With increased production capacity, SME is able to increase the number of marketing personnel so that the marketing area will become wider [15].

The presence of the semi-auto tea packer would boost the productivity of SME in Indonesia similarly to Thailand, which is engaged in the tea making business. Ones would be able to increase their tea production capacity (from 3-5 bags/min to 8-10 bags/min) and also increase the number of marketing personnel. The marketing area for the sale of tea products will also expand along with the increase in the number of production and marketing personnel. In addition, it is also necessary to apply other technologies that could support the advancement of SME in the tea making business. Marketing technology through digital marketing and business management technology will be indispensable in advancing SME in the tea making business. Marketing technology can be done through social media, e-commerce platforms and also marketplaces that can reach a wider marketing area. Business management technology will be needed so that SME can see the extent to which the business is developing, including the benefits obtained. It is hoped that by synergizing these technologies, it is hoped that SME in the tea-making business will become more advanced even though they are currently in the Covid-19 pandemic.

This research proposes a semi-auto tea packer with reasonably low cost (less than 350$USD), low installation area (less than 0.125 m^2), low electric power consumption (less than 120 W/hr.) and higher productivity (8-10 bag/min). In addition, the machine can be simply used with 220/230V, 50/60Hz AC power and produce tea bag with 2±0.5 g (standard size of most commercial tea bags). Detail of components and operations of the proposed tea packer prototype is described in Section 2, the experimental results and discussions are then presented in Section 3, and the conclusions in Section 4.

2. Structure of Proposed Tea Packer

2.1 Overview Components

Fig. 1 and Fig. 2 present the overview sketched design and overview prototype of the proposed tea packer under this research. The list of the components and their prizes of the proposed machine is shown in Table.1. The semi-auto tea packer prototype consists of 5 main parts. The first part (plate rotor) is a rotating part that will rotate when a sensor detects the tea of 2 g that falls down through the hole to the provided container. The second part is a weighting part (dispenser) that functions to control weight of tea to always be 2 g. The third part is a base (base) that supports all the parts and weight of the tea packer. The fourth part (controller) is a control box that controls operation of the tea packer including: electronic circuits, sensors and power supply. The fifth part (dissipater) is a blender that helps to dispose the tea not to rush to fall down into the hole. There are 15 core components in the machine (Table.1) with total cost of 9,875 Baht; where having the micro-controller (Arduino R), machine body and 12V dc gear motors as the top high cost for the proposed semi-auto tea packer.

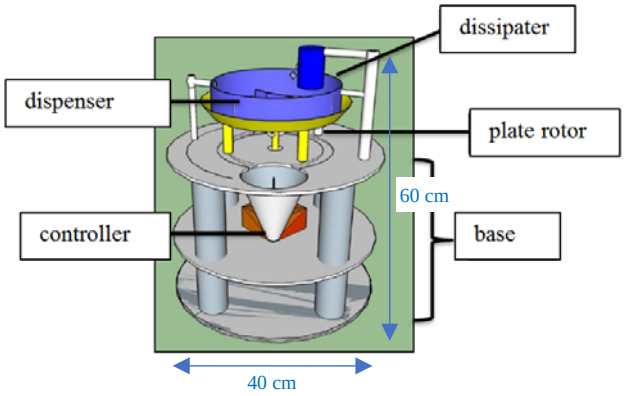

Fig. 1: Sketched design of the proposed tea packer

(a)

(b)

Fig. 2: Actual Prototype of the proposed tea packer: (a) side view and (b) semi-top view

No.	Component	Prize (Baht)
1	Arduino R	3,500
2	machine body	3,400
3	12V dc gear motors	1,800
4	12V/10A dc power supply	300
5	drive coupling	170
6	Infrared sensor	150
7	L298N motor drive	150
8	Aluminum plate	150
9	connectors	75
10	IC L293N	50
11	5V power Relay	50
12	Spiral wrapping band	30
13	micro-limit switch	20
14	IC 7805 voltage regulator	20
15	heatsink	10
	Total	9,875

Table 1 Component and prize list

2.2 Operations

Fig. 3 shows a diagram of the overall components and their connections of the proposed semi-auto tea packer. The machine starts when the infrared sensor detected the empty tea bag (see Fig.4a). The controller will then command both motors (plate rotor and dissipater) to rotate. The plate rotor will rotate with controlled speed and time across the dispenser ring and thus put 2 g of tea fall down into the hole (Fig.4b). After that both motors will stop and wait for the next tea bag. Fig. 5 depicted some examples of final tea bags.

3. Experimental Test

In order to test the performance of the proposed semi-auto tea packer, the following experimental tests were performed:

1. Productivity test (number of tea bags that were produced per minute).

2. Accuracy test (how accurate the weight of tea bags compared to standard 2 ± 0.5g).

3. Reliability test (motors and controller boxes were the key components for producing accurate weight of tea bags, the performance in terms of temperature heated was tested for this test).

; where tea power, tea bags, a scale, a watch and a thermometer were used for the tests.

Tables 2, 3 and 4 show experimental results regarding to the tests listed above, respectively. It could be summarized the results as follows:
(1) The test results on productivity on Table 2 shows that the proposed semi-auto tea packer could produce average 10 bag/min while the capability of producing varies between 8-12 bag/min in average. This productivity is about double when compared to the human operation (3-5 bag/min).

(2) The test results on accuracy test found that the proposed tea packer could achieved producing tea bags with weight within limited rang (+0.30/-0.09g) compared to ±0.5g of the standard requirement.

(3) The test results of machine reliability in terms of temperature heated on the motors and the controller boxes (most sensitive devices of the machine). The results show

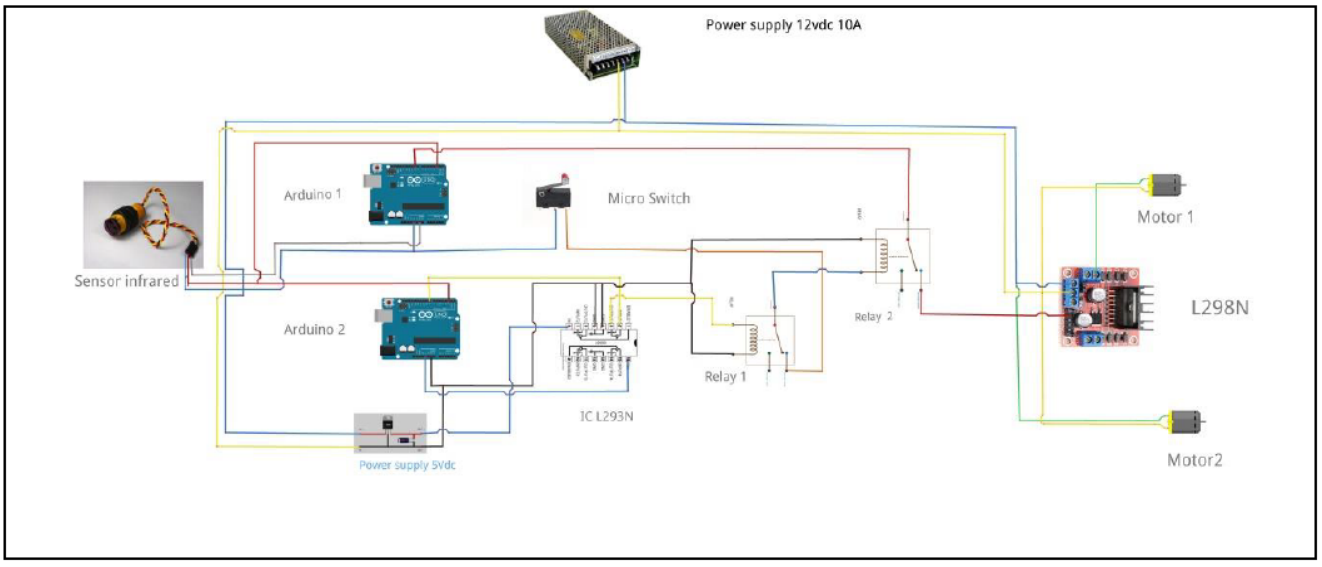

Fig. 3: Diagram of the overall components and their connections of the proposed tea packer

(a) (b)

Fig. 4: Operations of the proposed tea packer: (a) detected the tea bag stage and (b) dispensing tea into the tea bag

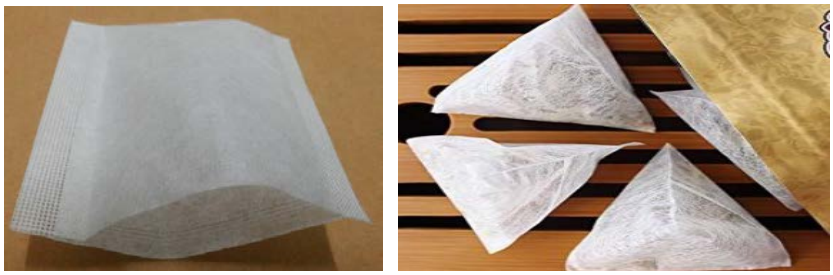

Fig. 5: some examples of the end product tea bags

that the temperature increases when the operating time of the machine increase. The temperature of the motors could reach 38 ºC when continuously operate for 360 minutes (6 hours) while temperature of the controller boxes reached at lower 32 ºC; having average of 33.9 ºC and 30.8 ºC, respectively. These temperature ranges are acceptable for air cool motors (upto 40 ºC for Standard NEMA) and controllers (upto 65 ºC for Standard electronics devices IEC-68-2-38).

Test No.	Number of Tea bags Productivity	
	Average (bag/minute)	Min-Max (bag/minute)
1-10	7	5-9
11-20	9	7-10
21-30	10	7-11
31-40	10	8-11
41-50	11	9-13
51-60	10	8-12
61-70	12	10-14
71-80	11	10-13
81-90	11	10-14
91-100	12	11-13
average	10	8-12

Table 2 Productivity test results

Test No.	Measured Weight	
	Average (g)	Min-Max (g)
1-10	2.16	1.82-2.24
11-20	2.02	1.71- 2.30
21-30	2.16	2.01-2.24
31-40	2.13	1.80-2.31
41-50	2.24	1.95-2.39
51-60	2.20	2.10-2.32
61-70	1.90	1.74-2.36
71-80	1.95	1.86-2.22
81-90	2.28	2.15-2.38
91-100	2.15	1.98-2.25
average	2.12	1.91-2.30

Table 3 Accuracy test results

Test time duration (minutes)	Average Measured Ambient Temperature	
	Motors (°C)	Controller boxes (°C)
30	29	29
60	30	30
90	31	30
120	32	30
150	34	31
180	33	31
210	35	32
240	34	31
270	36	32
300	38	32
330	37	31
360	38	31
average	33.9	30.8

Table 4 Reliability test results

4. Conclusions

The study, design and construction of a semi-auto tea packer in order to achieve low cost but high productivity for SMEs or local farmers have been presented in this paper. The proposed semi-auto tea packer prototype consists of 5 parts. The first part is a rotating part that will rotate when a sensor detects the tea of 2 g that falls down through the hole to the provided container. The second part is a weighting part that functions to control weight of tea to always be 2 g. The third part is a base that supports all the parts and weight of the tea packer. The fourth part is a control box that controls operation of the tea packer including: electronic circuits, sensors and power supply. The fifth part is a blender that helps to dispose the tea not to rush to fall down into the hole. The experimental results showed that the proposed tea packer prototype provided higher productivity (8-10 bag/min compared to human operation, 3-5 bag/min). The machine could achieve acceptable accuracy of weight for the tea bags with +0.30/-0.09g (compared to the required ±0.50g) and had high reliability by having low ambient temperature for the motors and controllers in the machine. Improvement on weight control should be noted as the further studied in the future work. The proposed machine would help to support SME business on agriculture and tea products for both Thailand and Indonesia.

5. Acknowledgements

The authors would like to express our sincere thanks to Walairukhavej Botanical Research Institute, Mahasarakham University, Thailand, for supporting the tea power for the tests and the Faculty of Engineering, Mahasarakham University, Thailand for fabrication and test equipment & measurement tools.

References

[1] K. Costley White, K. C. (2018). The Tea Party as Brand, *Oxford Scholarship* Online, Sep. 2018.

[2] Grigg, D. (2002). The worlds of tea and coffee: Patterns of consumption, *GeoJournal*, vol. 57, no. 4, pp. 283–294.

[3] Kakuda, T. (2018). Effects of tea galloyl catechins on the reduction of body fat, *Health benefits of green tea: an evidence-based approach*, pp. 116–123.

[4] Murase, T. (2013). Tea Catechins and Endurance, *Tea in Health and Disease Prevention*, pp. 717–726.

[5] Tokimitsu, I. (2004). Effects of tea catechins on lipid metabolism and body fat accumulation, *BioFactors*, vol. 22, no. 1–4, pp. 141–143.

[6] Harada, K. (2011). "Antioxidant activity of the giant jellyfish Nemopilema nomurai measured by the oxygen radical absorbance capacity and hydroxyl radical averting capacity methods, *Molecular Medicine Reports*, Jun. 2011.

[7] Cui, L. Li, M. Gong, Z. and Xiao, W. (2011). Optimized extraction of tea caffeine from green tea leaves using dichloromethane, *Journal of Hunan Agricultural University*, vol. 37, no. 5, pp. 562–566.

[8] Hayashi, N. (2013). Objective Evaluation of the Taste Intensity of Tea by Taste Sensors, *Tea in Health and Disease Prevention*, pp. 103–113.

[9] .Recycling for tea bags (1996), Filtration & Separation, vol. 33, no. 7, p. 524.

[10] Kosman, V. ozharitskaya, O. and Urakova, I. (2007). Comparison of ginkgolide, bilobalide and flavonoid content in tea from Ginkgo biloba leaf tea-bags with standardized dry extract drugs, *Planta Medica*, vol. 73, no. 09.

[11] Cleverdon, R. Elhalaby, Y. McAlpine, M. Gittings, W. and Ward, W. (2008). Total Polyphenol Content and Antioxidant Capacity of Tea Bags: Comparison of Black, Green, Red Rooibos, Chamomile and Peppermint over Different Steep Times, *Beverages*, vol. 4, no. 1, p. 15.

[12] Terminology used in the Tea Research. (1998. Tea Processing Technology, *Chagyo Kenkyu Hokoku* (*Tea Research Journal*), no. 86, pp. 57–93.

[13] Driem G. V., Tea Terroir and Tea Cuisine, *The Primordial Origins of Tea*, Jan. 2019.

[14] Baruah, P. (2017). Types of Indian Tea, Production and Marketing of Traditional and Handmade Teas of Assam, India, *Journal of Tea Science Research*, 2017.

[15] Haryanto, Aidil, Yose Rizal Kurniawan, dan Wawan Agustina (2014, December). Peran Teknologi Tepat Guna Pada Pengembangan UKM, Studi Kasus: Implementasi Mesin Pencetak Kerupuk Pada UKM Kerupuk Terung Merk Baraya Di Kota Tegal. *Prosiding Konferensi dan Seminar Nasional Teknologi Tepat Guna Tahun*. 2014.

Biographies

Krit Lertlam was born in 1996 at Kalasin province, Thailand. He graduated with the Bachelor Degree of Electrical Engineering from Faculty of Engineering, Mahasarakham University, Thailand, in 2018 and expects to complete his Master Degree of Electrical and Computer Engineering from the same university in 2020 under the scholarship of Work Integrated Learning (WIL) project.

Sutiwas Duenjum was born in 1996 at Prachin Buri province, Thailand. He graduated with the Bachelor Degree of Electrical Engineering from Faculty of Engineering, Mahasarakham University, Thailand, in 2018. He has currently worked at Hitachi Consumer Products (Thailand), Ltd., Prachin Buri, Thailand.

Denny Purnomo graduated from a bachelor's degree in Management at Bina Nusantara University Jakarta, Indonesia in 2006 with the predicate Cumlaude. In 2018, he was accepted for a Masters course in the Department of Master of Management, Faculty of Economics and Business, Jenderal Soedirman University, Purwokerto, Indonesia and graduated with the cumlaude predicate in 2020. During his Masters course in the Department of Management, Faculty of Economics and Business, Jenderal Soedirman University, he was active. become a member of the Unsoed Research Center as a Research Assistant, active in the 5TH International Conference on Rural Development and Entrepreneurship (ICORE) activities in 2019 as a Committee and Presenter, active in Rural Development Project (RDP) activities as chair of RDP, active in participating in Excursion Study activities at Burapha University Thailand in 2019, and was active in the Pusbangdesmas LPPM Unsoed as a Trainer and Research Assistant. Currently, he teaches as a lecturer in the Digital Business study program at the Telkom Institute of Technology in Purwokerto, Indonesia.

Chonlatee Photong received his B.Eng. from Khon Kaen University, Thailand in 2001. He has been worked at Sony Device Technology (Thailand) Co., Ltd. and Seagate Technology (Thailand) Co., Ltd. for 3 and 2 years, respectively, after that. He received his M.Sc. in Power Electronics and Drives and Ph.D. in Electrical and Electronic Engineering from University of Nottingham, UK, in 2007 and 2013, respectively. He is currently the associate dean for Administration of Graduate School, Mahasarakham University, the head of Solar Energy and Energy Resources (SEER) Research Unit, the program director of Practical Engineering (Continuing Program), an associate professor in Power Electronics and Drives at the Faculty of Engineering, Mahasarakham University, Thailand and an IEEE member (Industrial Electronics Society; IES). His research interests include power electronics, power converters for renewable energy conversion, and electrical machines and drives.