Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

A Prototype of Automated Chayote Peeling Machine

Tran Vu Minh[1], *Tran Thanh* Tung[2]

1 –School of Mechanical Engineering, Ha Noi University of Science and Technology, Ha Noi, Viet Nam

2 -Faculty of Engineering Mechanics and Automation, VNU University of Engineering and Technology, Hanoi, Viet Nam

Corresponding author contact: tranthanhtung@vnu.edu.vn

Abstract. *Fruit peeling seems a simple performance, but it is the consist of many elements such as the peeler, the way we grasp and move the blade and cutting speed, etc. - all these factors play a role, and interact with each other. This paper describes the prototype of a chayote peeling machine. The machine has been designed with a simple and low-cost approach. To improve chayote peeling rate and ensure pulp quality, a proposed structure was designed, manufactured and tested in laboratory. The experimental results are examined to demonstrate the efficiency of the peeling machine. It proves that the proposed machine could be widely applied in the fruit peeling technology.*

Keywords: Chayote, peeling machine, prototype, mechanical engineering, CAD.

1 Introduction

In Vietnam, the Chayote is a very popular fruit but was eaten like a vegetable. Chayote may be processed into different forms (boiled, fried) for consumption as food, thus cutting Chayote skins is something that the majority of Vietnamese have done, and for some, it is a daily occurrence at home, restaurant, and hotel (European Union, 2020; Greg et al., 2008; Wikk el al., 2003; Huong el al., 2013; Nguyen et al., 2018; Quan, 2009). Therefore, peeling is one of the most important unit operations in chayote processing. Typically, this is accomplished with a knife, followed by pressing on the Chayote with your hand to separate the peel from the pulp, as shown in Figure 1. This peeling method not only causes more meat loss, but also can cause injury when the knife hits the hand (Krstic, 2018; Henry, 2012). Every year, about thousands of people end up in emergency rooms with injuries they receive by using kitchen knives (Health Encyclopedia). Thus, having an automated machine perform the aforementioned tasks is an absolute necessity in order to save both labor and time.

A common trend is to use an automatic peeler machine instead of peeling by hand. The world's automatic fruit peeling machines have been researched and applied for a long period of time (Wang et al., 2019; Ahmadabadi et al., 2017; Zheng et al., 2018; Li et al., 2018; Pagán et al., 2011; Rock et al., 2011; Wang et al., 2018). There are many different kinds of peelers in the world. They all peel things, but their functions, output, and results can be very different. To our knowledge, however, these machines was rarely applied in chayote until now. Moreover, these types of machines are unfamiliar to many people in the Vietnamese market, where the majority of machines sold are simple manual cutting machines. Additionally, these machines have a number of disadvantages, including a reduction in productivity and quality, as well as a working space that is limited to the size of the fruit. The article proposes an automatic Chayote peeler model with the goal of reducing manual labor, increasing productivity, and ensuring food safety. The machine has a straightforward structure and is simple to operate, making it ideal for use in households.

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

Fig. 1. Cutting the Chayote by hand.

Cutting fruit is only difficult, but it is also a time-consuming task. This work required dexterity, but it also takes time (Knife news. 2015; Stone et al., 2019). Additionally, it is a time-consuming task on average, it takes about 5-10 minutes to cut a Chayote, depending on the fruit cutter's skill and the knife's sharpness. Cutting too thickly can result in significant pulp loss, while cutting too thinly can be challenging and the knife can slip and injure the people. As a result, it is critical to cut Chayote in the most efficient manner possible to avoid core loss. Traditional Chayote cutting will be very slow and time consuming, and the Chayote pieces will be unappealing. As a result, an automatic Chayote cutter is required to increase cutting speed. Because Chayote is a fruit with complex mechanical properties and an irregular shape and size, the cutter set will be designed to cut fruit of any size with minimal loss. The article proposes an automatic Chayote peeler to eliminate the need for manual peeling. The model is simple in design, low in cost, and simple to operate, making it ideal for household use.

2 Structure of Chayote peeling Machine Structure

To maintain food safety and hygiene, the Chayote peeler will be designed with a fully automatic priority direction, with only the knife coming into contact with the Chayote during operation. Additionally, given the variety of Chayote sizes, the machine's knife mechanism must be capable of adjusting itself to cut the most optimal slice. This means that a reasonable cutting regime will be used to ensure a clean cut of the Chayote grass and minimal pulp loss. To begin designing a Chayote peeler, the research begins with the extraction of data from the Chayote, such as its size, mechanical properties, and so on.

The model of the chayote peeling machine is based on the operating principle of the lathe machine, with the chayote serving as the rotating workpiece, the knife moving in a reciprocating motion, and the chayote shell serving as the chip. The machine consists of three major components: the knife mechanism, the locating shaft, and a push-pull mechanism that allows the cutter to contact the fruit profile properly, as shown in Figure 2.

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

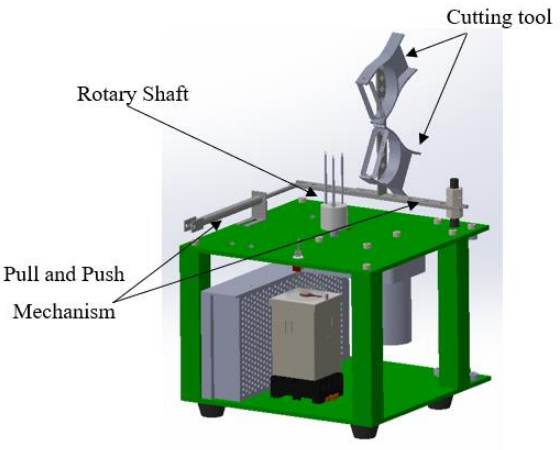
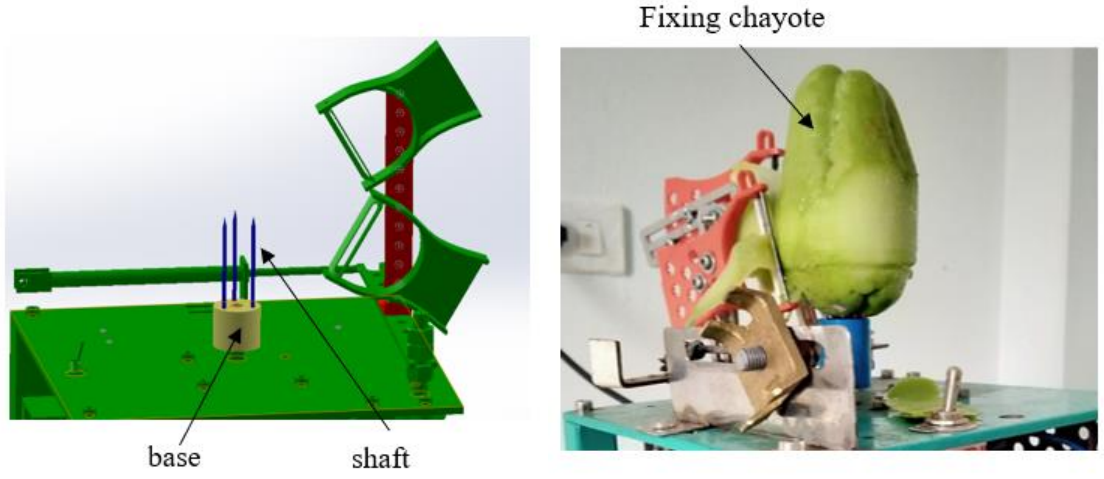


Fig.2. Machine Model.

3 Design of a chayote peeling machine

The operation of the machine is very simple. A Motor transmits power to the rotating chayote through a shaft. The chayote fixing jig includes a base 2 to be fixed on a table, and three shafts provided on the base for fixing a chayote, as shown in Figure 3. Distance between a cutting tool and base depends on size of fruit. Normally, a chayote has dimensions as shown in Figure 4. Chayote was purchased from the supermarket (Hanoi, Vietnam), with a maximum width range of 40–72 mm and a height range of 70–120 mm. Therefore, Figure 5 shown that the slide which could push and pull the cutting tool has the same dimension, respectively.

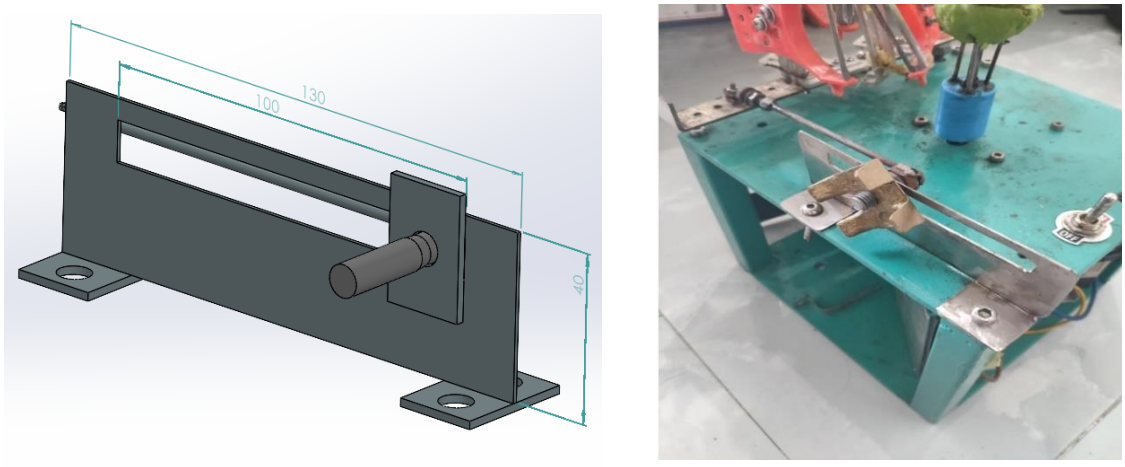


(a) **(b)**

Fig.3. Rotating shaft with chayote fixing. (a) CAD model; (b) manufactured chayote peeling machine.

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

Fig. 4. Typical Vietnam chayote sizes.



(a) **(b)**

Fig.5. The slider and the push and pull mechanism. (a) CAD model, (b) Real production.

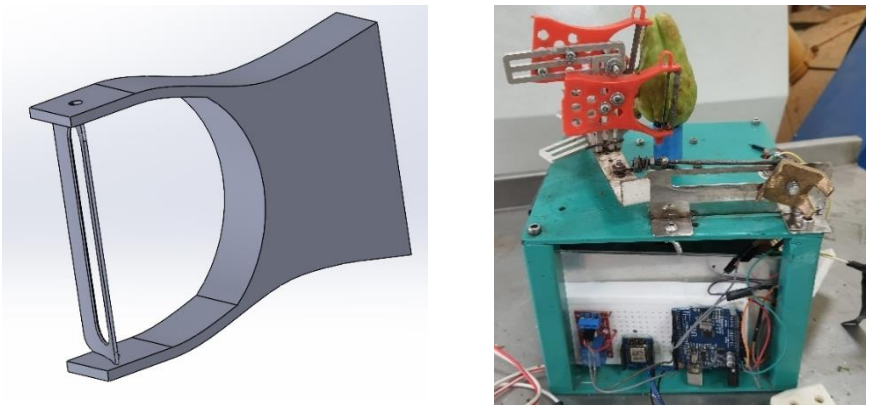
The cutter is designed according to the same shape as the fruit grater on the market, there are a total of two cutters built on the machine. The blades are arranged so that the entire shape of the chayote can be cut, as shown in Figure 6. The materials of parts are readily available in the market.

The paper presented the cutting parameter with chayote's rotational speed as an average of 40 revolution per minute. Equation between power and torque the following way:

$$Power = \frac{2\pi n M_t}{60 \times 10^6} \quad (1)$$

In which
Power: transmitted power (kW)
M_t: Torque (N-mm)
n: Speed of rotation (rpm). This was selected to be 500 rpm
Newton's laws of motion relate the torque and moment of inertia in rotational motion
$M_t = I\alpha$
where
I: moment of inertia of the chayote
α: angular acceleration of the chayote (rad/s^2)

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)



(a) (b)

Fig.6. The cutting tool. (a) CAD model, (b) Cutting tools locating on the machine.

To ensure the required torque, a DC gearmotor and a switching mode power supply (SMPS) are chosen as shown in Figure 7. Table 1 and Table 2 show the specification of the motor and the power supply, respectively. The Figure 8 presents the location of gear motor and electricity board in the machine.

(a) (b)

Fig.7. Electric part. (a) DC gearmotor, (b) Switching mode power supply

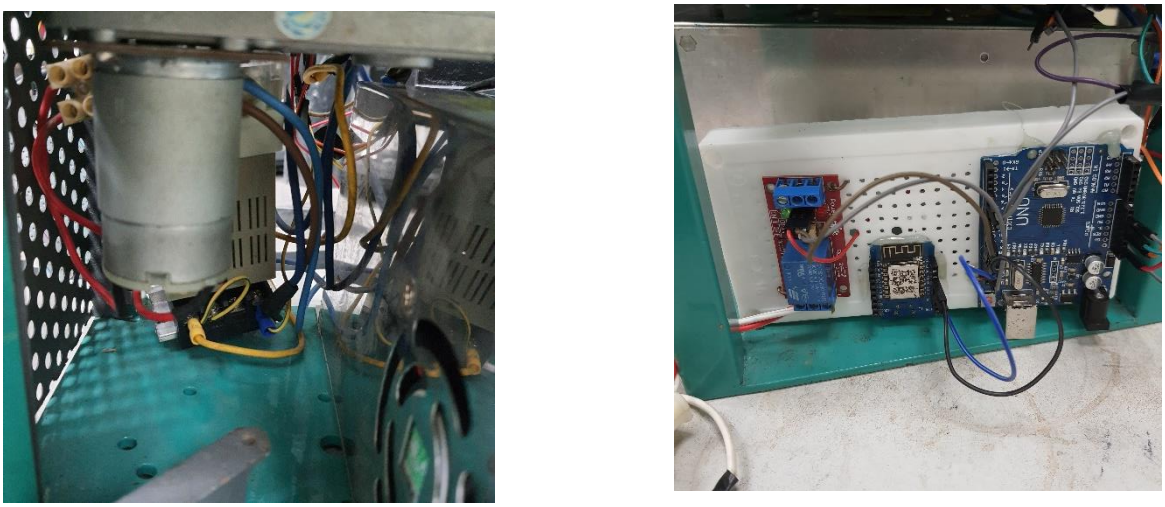
Table 1. DC gearmotor JGB37-3530 specification.

Specification	Value
Operating voltage	between 6 V and 15 V
Free-run speed at 24 V	1600 RPM
Stall current at 24 V	1.2 A
Stall torque at 24 V	1 kg.cm
Gear ratio	1: 6.25
Reductor size	19 mm
Weight	177 g

Table 2. Switching mode power supply S-120-12 specification.

Specification	Value
Output Power	101 - 200W
Input Voltage	180-264VAC
Output Voltage	12V
Output Frequency	10-500hz
Output Current	10A
Size	199*98*38mm

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

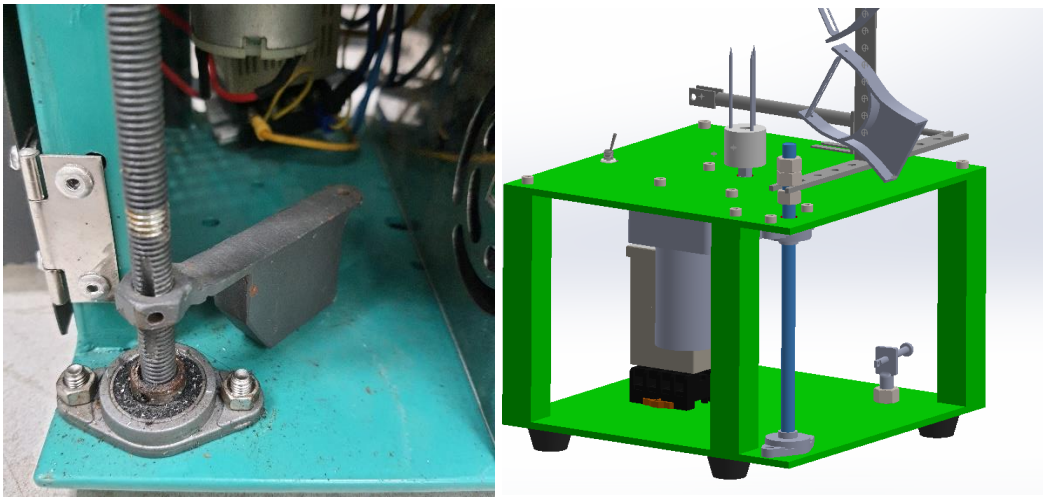


(a) **(b)**

Fig.8. Electric parts location. (a) DC gearmotor, (b) Electricity board

3.1 Formatting of Mathematical Components

In order to evaluate the torque, the screw needs to be selected. A commercial spindle and lead screw nut have been chosen to build the machine as shown in Figure 9. The lead screw enables adjusting the cutter's height to accommodate the chayote's size.



(a) **(b)**

Fig.9. The spindle and lead screw nut.

The equation for the torque required to raise a load with a lead screw (Shigley, 2011) as

$$T_r = \frac{Fd_m}{2}\left(\frac{l+\pi f d_m \sec\alpha}{\pi d_m - f l \sec\alpha}\right) \quad (2)$$

where l is the lead of the screw, secα =1/cosα with α is the lead angle and dm is the major diameter and f the friction coefficient screw and nut, was selected as 0.3.

The first is to adjust the slider so that the tip of the steel rod connected to the blade carrying system will pull the paring blade into the fruit peel. Then turn on the power, the power on leads to timer which is responsible for supplying power to the whole machine system. After the timer closes, electricity will go to the motor carrying the fruit to make the motor rotate. After the timer runs out of the set time, it automatically switches to the open state, disconnecting the entire system, the fruit could be taken out.

Technical University of Varna Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

3.2 Peeling performance and product quality evaluation

To evaluate the peeling performance, there was many variety criteria, such as level of peeling hardness, The surface area of fruit before and after peeling (peel removal), The weight ratio of fruit before and after peeling (peeling losses), the skin thickness after peeling, and cookable, have been examined by many researchers (Garcia et al., 2006; Li et al., 2014; Shen et al., 2020). The definition of indices is expressed in Table 3 as follow:

Table 3. Peeling quality performance evaluation.

Criteria	Definition
1. Peeling hardness level	Hardness of peel removal, from easy to hard
2. Peel removal (%)	The surface area of fruit before and after peeling.
3. Peeling flesh losses (%)	The weight ratio of fruit before and after peeling
4.Peeling skin thichness (mm)	Removal of the skin is only possible in a few areas ; other areas require considerable effort.

4 Result and Discussion

The peeling easiness of this research is shown in Table 4.

Table 4. Six peeling easiness levels.

Peeling level	Definition
1. Perfectly easy	The skin can be removed extremely easy; can peel a large piece of skin
2. Very easy	The skin can be eliminated without difficulty.
3. Easy	In most areas, it is possible to remove the skin; certain areas require minimal effort.
4. Moderate	Removal of the skin is only possible in a few areas; other areas require considerable effort.
5. Hard	In the majority of regions, peeling the skin is difficult; certain areas remain unpeeled.
6. Very hard	Only small skin can be peeled; removal of the skin in all areas was challenging.

Figure 10 shows the completed prototype, which is proposed in this study

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

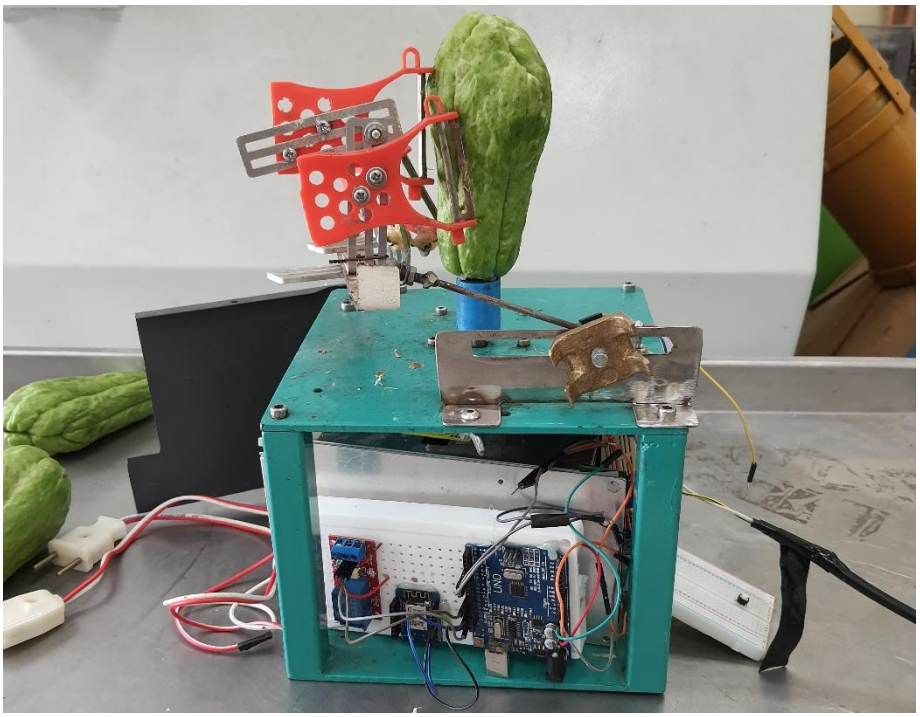
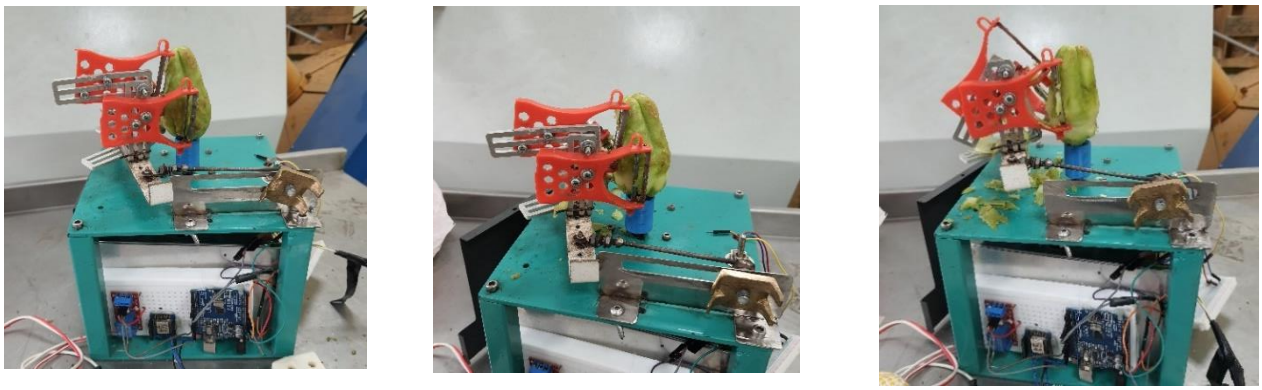


Fig. 10. Completed prototype of chayote peeling machine.

Experimental cutting process is tested on many times with many types of chayote with different shapes and sizes to evaluate the performance of the machine. Experimental results showed that a minimum cutting speed of 300 rpm is needed to break the peel and separate it from the pulp.

The machine can cut most common types of chayote in Vietnam, as shown in Figure 11. In case the chayote is too big to cut the entire profile, this case can be solved by turning the fruit back and cutting again or can raise the cutting tool mechanism, as shown in Figure 12. The time for one cut is about 3 seconds, which is a very fast speed compared to cutting by hand.



(a) (b) (c)

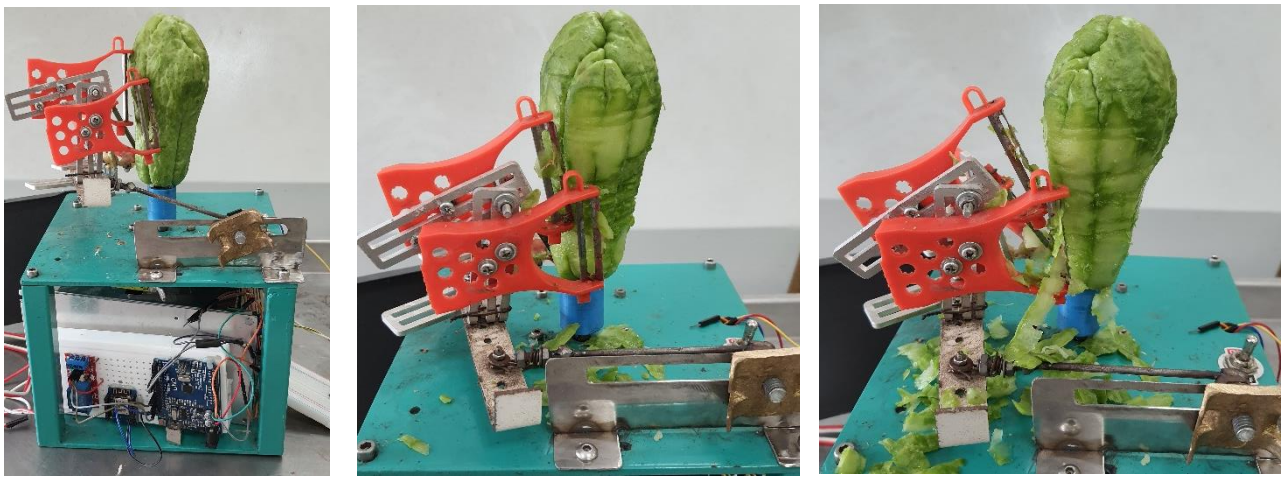
Fig. 11. Sequential from Experimental Test 1, (a) Starting, (b) Cutting, (c) Finishing

Effective peeling of the machine was achieved for chayote at 150-400 rpm shaft speeds and time ranges considered. At the end of fabrication, a good peeling and cutting machine was made out of the materials and methods that were available. When compared to peeling by hand, the machine works better overall (level 4 instead of level 3).

Production and maintenance expenses are relatively inexpensive. Consequently, the machine will be well received by industries due to its performance, affordability, and ease of use. The proposed machine helps labor costs and satisfies the requirements of households and industries. The machine is user-

Technical University of Varna
Annual Journal
https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

friendly, safe, and simple to maintenance. The technology is inexpensive and less expensive than existing peeling machines. It has low operational expenses. The comparison results of peeling a chayote by manual and by proposed machine is shown in Table 5. Consequently, the machine was a success.



(**a**) (**b**) (**c**)

Fig.12. Sequential from Experimental Test 2, (a) Starting, (b) Cutting, (c) Finishing

This section is not mandatory but may be added if there are patents resulting from the work reported in this manuscript.

Table 5. Comparison results of peeling manual and machine

Peeling method	Time peeling (min)	Peeling easiness level
Manual	6-8	3
Peeling machine	1-2	4

5 Conclusions

This paper presented the prototype of a chayote peeling machine. In this research, a chayote peeling machine was developed and its performance evaluation was carried out. A new design structure was proposed. The machine is simple, and easy to use for everyone. The prototype has been tested to demonstrate that the proposed machine is able to peel the common chayote. The machine model that can peel of chayote is very convenient and can completely replace hand peeling.

References

A. Pagán, J. Conde, J. Pagán, A. Ibarz (2011). Lemon peel degradation modeling in the enzymatic peeling process. *Journal of Food Process Engineering*, 34, 383-397. https://doi.org/10.1111/j.1745-4530.2009.00363.x

C. Rock, W. Yang, R. Goodrich-Schneider, H. Feng (2012). Conventional and alternative methods for tomato peeling. Food Engineering Reviews, 4, 1-15. DOI: 10.1007/s12393-011-9047-3

European Union, The Food and Beverage Market Entry Handbook: Vietnam, 2020. Doi: 10.2818/067189.

Fenghe Wang, Yechun Ding, Weijun Xie, Deyong Yang (2019). Design and experimental study of a separating machine for seed and peel of camellia oleifera fruit, *IFAC-PapersOnLine*, 52 (30), 87-91. https://doi.org/10.1016/j.ifacol.2019.12.502.

https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

Garcia, E., & Barrett, D. M. (2006). Peelability and yield of processing tomatoes by steam or lye: Peeling of processing tomatoes: Lye and steam. Journal of Food Processing and Preservation, 30(1), 3–14. https://doi.org/10.1111/j.1745-4549.2005.00042.x

Health Encyclopedia. Be Careful with Kitchen Knives. https://www.urmc.rochester.edu/encyclopedia/content.aspx?contenttypeid=1&contentid=263 (Access 01 June 2022)

Henry, A. (n.d.). Why Dull Knives are More Dangerous in the Kitchen. https://lifehacker.com/why-dull-knives-are-more-dangerous-in-the-kitchen-5968985 (Access 01 June 2022)

Hosein Nouri-Ahmadabadi, Mahmoud Omid, Seyed Saeid Mohtasebi, Mahmoud Soltani Firouz (2017). Design, development and evaluation of an online grading system for peeled pistachios equipped with machine vision technology and support vector machine, *Information Processing in Agriculture*, 4 (4), 333-341, https://doi.org/10.1016/j.inpa.2017.06.002.

Jalal Eskandari, Ali M. Kermani, Shahriar Kouravand, Payam Zarafshan (2018). Design, fabrication, and evaluation a laboratory dry-peeling system for hazelnut using infrared radiation. *LWT - Food Science and Technology*, 90, 570-576.

Johnson, Greg & Weinberger, Katinka & Wu, Mei. (2008). The Vegetable Sector in Tropical Asia: Vietnam, 2008

Knife News. (2015, September 25). This stubby knife handle thinks you've been holding your kitchen knives all wrong. https://knifenews.com/fini-cutlery-stubby-knife-handle-thinks-youve-been-holding-your-kitchen-knives-all-wrong/ (Access 01 June 2022)

Li, X., Zhang, A., Atungulu, G. G., Delwiche, M., Milczarek, R., Wood, D., ... Pan, Z. (2014). Effects of infrared radiation heating on peeling performance and quality attributes of clingstone peaches. *LWT - Food Science and Technology*, 55(1), 34–42. https://doi.org/10.1016/j.lwt.2013.08.020.

Nguyen T.M., Le N.T.T., Havukainen J., Hannaway D.B (2018) Pesticide use in vegetable production: A survey of Vietnamese farmers' knowledge. *Plant Protect. Sci*., 54, 203–214

Pham Thi Thu Huong, A.P. Everaarts, J.J. Neeteson, P.C. Struik (2013). Vegetable production in the Red River Delta of Vietnam. I. Opportunities and constraints. NJAS - Wageningen Journal of Life Sciences, 67, 27-36, https://doi.org/10.1016/j.njas.2013.09.002.

Richard T. Stone, Olivia Janusz, & Thomas M (2019). Schnieders Iowa State University. Ergonomic Analysis of An Affordance Tool for Modern Kitchen Knives. *Proceedings of the Human Factors and Ergonomics Society 2019 Annual Meeting*, 2019.

Shigley, J. E. Shigley's mechanical engineering design. Tata McGraw-Hill Education, 2011

S van Wijk. The market for vegetables in North Vietnam - WUR eDepot.

Truong Tan Quan (2009). Transition From Subsistence Farming to Commercial Agriculture in Quang Binh Province, Vietnam. Lincoln University.

W. Wang, L. Wang, Y. Feng, Y. Pu, T. Ding, X. Ye, et al. (2018). Ultrasound-assisted lye peeling of peach and comparison with conventional methods. *Innovative Food Science and Emerging Technologies*, 47, 204-213. DOI:10.1016/j.ifset.2018.02.016

Xuan Li, Zhongli Pan, Griffiths G. Atungulu, Xia Zheng, Delilah Wood, Michael Delwiche, Tara H. McHugh (2014). Peeling of tomatoes using novel infrared radiation heating technology.

https://doi.org/10.29114/ajtuv.vol6.iss2.285
Vol.6 Issue 2 (2022)
Published: 2022-12-31
ISSN 2603-316X (Online)

Innovative Food Science & Emerging Technologies, 21, 123-130. https://doi.org/10.1016/j.ifset.2013.10.011

Yi Shen, Ragab Khir, Delilah Wood, Tara H. McHugh, Zhongli Pan (2020). Pear peeling using infrared radiation heating technology. *Innovative Food Science & Emerging Technologies*. 65, https://doi.org/10.1016/j.ifset.2020.102474

Zhang Zheng, Wang Xiaoxi, MA Sen (2018). Effects of Peeling with Flexible Alloy Blade on Naked Oats. *Grain & Oil Science and Technology*, 1 (3), 131-137, https://doi.org/10.3724/SP.J.1447.GOST.2018.18038.

Zee Krstic (2018). Here Are the Kitchen Tools Most Likely to Harm You. https://www.cooking-light.com/news/what-are-the-most-dangerous-kitchen-items-accidents (Access 01 June 2022)