Design and Construction of a Cassava Tuber Knife Peeling Unit

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Abstract

Peeling of cassava tubers is one of the important steps in processing of cassava chips. The peeling is still manual, which has low capacity and is therefore insufficient for production needs. This project aims to design and fabricate a unit for cassava tuber knife peeling. The unit consists of a structure, power and transmission, and a knife peeling set. The study conditions were at 70, 80 and 90 rpm of knife rotating speed, with 3 different knife peeling types and 2 levels of spring stiffness of knife peeling (8.21 and. 17.19 N/m). The result shows that the most suitable conditions were 90 rpm of knife peeling speed, using a second knife peeling type and a spring stiffness of 17.19 N/m. The capacity was 10.43 seconds/tuber. The peeling efficiency was 90.3 and the percentage of flesh loss was 3.63

Keywords : Cassava tuber, Knife and Peeling

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1. Introduction

Cassava is one of the world's most important food crops. Cassava is grown mainly in the tropical parts of Africa, Malagasy, Indonesia, South India, Philippines and Thailand. The cassava is the main economically useful part of the country. Cassava-based dishes are widely consumed wherever the plant is cultivated. It is one of the most drought-tolerant crops, capable of growing on marginal soils. Apart from the importance of the cassava tuber as a constituent of human food, it has many non-food uses and it has become a foreign exchange earner for the producing countries [1,2] There are two major types of cassava, though they are used similarly. Sweet type cassava is one of the two major varieties of cassava and must be cooked properly to detoxify before eaten. Cassava can be cooked in many ways. The tuber of the sweet variety has a delicate flavor and can replace potatoes. It can be made into flour that is used in bread, cooked to a dry, often hard or crunchy meal toasted in butter, or eaten alone as a side disc.

Sweet type cassava is popular, and processing of sweet type cassava includes peeling, grating, boiling/parboiling, drying, milling, sieving, extrusion and frying to obtain such products like flour, dried chips, grates and etc. Manual operation in cassava processing is practiced because there is no locally available machinery. Before mechanizations, manual tools were used for peeling such as knives and wood tools. It is the most common method of peeling cassava tubers today. It was revealed that cassava peeling is still largely done manually. However, woman and teenage girls normally involve in the peeling of tubers. Manual processing (peeling, grating, pressing, etc.) of cassava is laborious and intensive, such as manual peeling by shearing with a knife. Manual operation of peeling is tedious and operated by hand to facilitate removal of periderm of cassava tubers. The output of the skilled person for manual peeling is about 25 kg/hr, with a loss of 25-30% of weight in the peels. The process is slow and labour intensive [3], which invariably leads to low productivity.

Peeling is the first process from harvest to processing which is a very important operation. In the cassava peeling operation, both the periderm and the cortex are removed as waste, and the central portion of the tuber left as the desired output. Mechanization of this process has the potential of driving increased cultivation of cassava and generating products with high hygienic standard, product quality, processing efficiency, minimum loss of tubers and increased processing rates. Cassava peeling can be done in different methods.

The development of a peeling machine for cassava can be done by using rotating blades which peel the rotating cassava tubers, and evaluating the prototype's performance. The parameters used in the testing are linear speed of blades, speed of the roller and cassava tuber size, whereas the important indicators are net cassava flesh ratio, peeling ratio, rate of peeling (kg/h) and peeling efficiency percentage.

It was found that by using cassava tubers with 41-70 mm diameter and 120 mm length, 4.5 m/s linear speed of blades, 70 rpm speed of the roller and 0.22 m/s linear speed of the chine transmission, the prototype gives net flesh ratio of 0.88, peeling ratio of 0.86, rate of cassava peeling of 224 kg/h and peeling efficiency of 75 percent, which invariably lead to low capacity [3]. Abrasive peeling using a stationary outer abrasive drum and a rotating inner abrasive drum based on a batch capacity of 8.5 kg and cut tuber length of 200 mm. and diameter of 90 mm. An average peeling efficiency recorded was 70.45 percent, while the average flesh loss was 5.09 percent and broken cassava was estimated to be 2 percent. This machine consists of a roller with 200 mm. diameter and 900 mm length. The shaft has 25 mm diameter and runs through the roller. The results show the capacity of the machine as 1050 kg/h. This gave this machine an estimated processing time of 0.33 seconds/kg [4]. Therefore, the research aims to design and develop a cassava tuber knife peeling unit for the cottage industries in order to meet the processing needs of the farmers. Processing machinery is made to replace the manual method and to increase product output, respectively. Processing design and construction of a cassava tuber knife peeling unit are made to replace the manual method and to increase product output in order to meet the required demand for food, fiber and materials. Appropriate mechanization is extremely necessary in order to achieve the desired end product.

2. Materials and Methods

2.1 The physical properties of cassava

The cassava peeling has become the major problem of cassava processing worldwide. There are different varieties of cassava tuber, which is attributed to the irregularity in shape and size. The cassava tuber properties are important on the relationships that exists many parameter in designing an efficient and performance of a cassava peeling machine [5,6]. The samples of this study were sweet type cassava (5 minutes is the local name of the variety). The cassava tubers used in the experiment were harvested in Khonkaen province, Thailand. Dimensions of cassava tubers which are the length, diameter and peel thickness were measured. (Fig. 1 and Fig. 2)

2.2 Principle of the operation

The principle of the cassava tuber knife peeling unit was the use of a knife to rotate around a cassava tuber while it was fed from the upper to lower knife set. The cassava tuber had 150 mm length and 75 mm diameter at the upper knife set and 60 mm minimum diameter at the lower knife peeling tube set (taper shape of tube) with the blade inclined at 30 degrees by tangent against the cassava tuber. Other components include frame, motor, transmission system. (Fig.3 and Fig. 4)

2.3 Experiment

The cassava tuber knife peeling unit was tested with three main factors of machine operation such as knife rotating speed (70, 80 and 90 rpm), three different knife types, 1st type, there is a peels removing port, 10 degree with the tuber horizontal-axis, 2nd type, there is a peels removing port, parallel with the tuber axis and 3rd type, there is not a peels removing port, 10 degree with the tuber horizontal-axis. (Fig.5) and two different levels of spring stiffness (8.21 and 17.19 N/m). Therefore, there were 18 experiments with 3 replications. The cassava tuber sizes used for the experiment ranged between 30-60 mm. diameters with average 200 mm length.

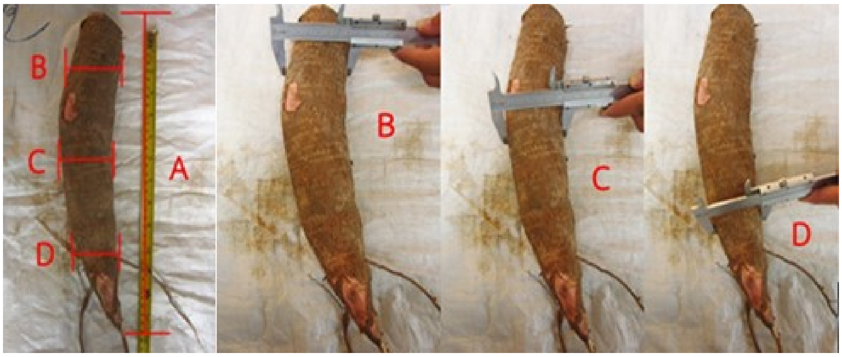

Fig. 1. Dimension of cassava tuber measurement

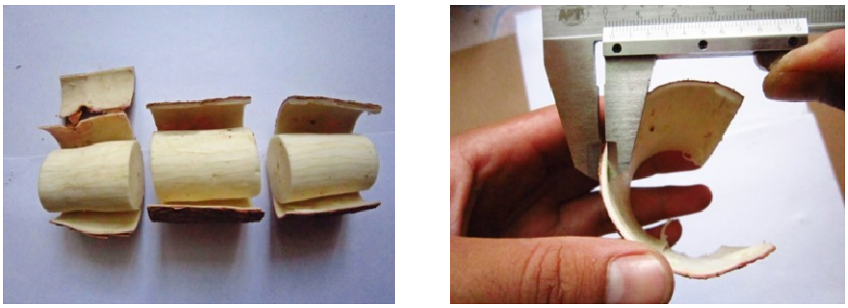

Fig. 2. Peel thickness measurement.

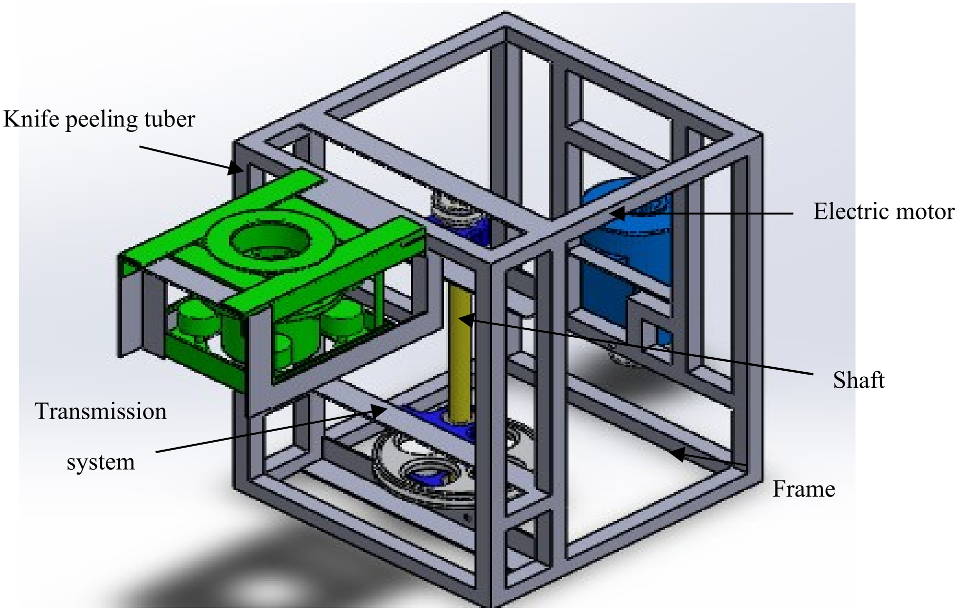

Fig. 3. Structure of a cassava tuber knife peeling unit

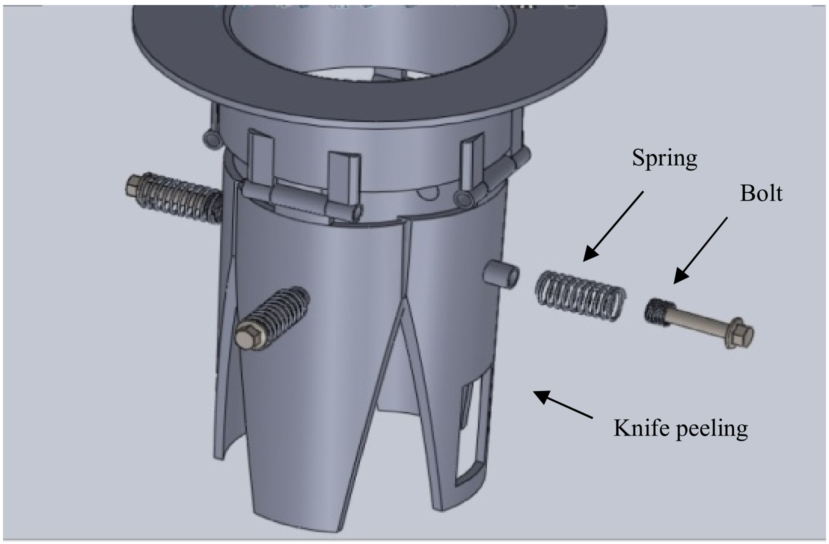

Fig. 4. The knife peeling tuber set

1^{st} type 2^{nd} type 3^{rd} type

Fig. 5. The three different types of knife for this study

2.4 Equations used in experiment

Calculations used in the trial runs were as follows;

(1) Peeling capacity (PC, second/tuber)

$$PC = \frac{\text{Total time taken to peel.}}{\text{Weight of flesh removed by machine}}$$

(2) Peeling efficiency (PE, %)

$$PE = \frac{\text{Area of peels removed by machine.}}{\text{Total peels.}} \times 100$$

(3) Flesh loss of tuber (FL, %)

$$FL = \frac{\text{Flesh loss of peels removed by machine.}}{\text{Total weight of flesh}} \times 100$$

3. Results and Discussion

3.1 Physical properties

The results of physical properties of cassava tubers obtained from table 1 indicate the maximum and average diameter at 68.00 and 50.10 mm, respectively, and the maximum and average peel thickness at 3.28 and 2.45 mm, respectively.

Table 1 Physical properties of cassava tubers relevant to peeler design.

Properties	Length (mm)	Diameter (mm)			Peel Thickness (mm)			Diameter of Peeled Tuber(mm)		
		head	Mid	Tail	head	Mid	Tail	head	Mid	Tail
Minimum	240.00	34.00	39.00	32.00	1.83	1.82	1.87	32.00	33.50	29.50
Maximum	390.00	60.00	68.00	58.00	3.28	3.03	2.88	62.00	57.50	48.00
Average	338.00	47.50	50.10	40.30	2.49	2.53	2.45	43.75	44.50	38.15
Stdv.	44.42	9.35	9.41	7.86	0.47	0.34	0.29	9.34	8.25	6.21

3.2 Performance test

In Fig. 6 and Fig. 7, the results of the effect of knife type and knife rotating speed on peeling efficiency and flesh loss at two different levels of spring stiffness were 17.19 N/m and 8.21 N/m, respectively. The peeling efficiency (%PE.) increased with increased high knife rotating speed. The 2nd knife type had high PE. with the 90 rpm of knife rotating speed and 17.19 N/m of spring stiffness which was the best condition for operation. It gave the highest PE. of 90.30% and flesh loss of cassava tubers of 3.36%., which is more than many research of cassava peeling machine about 63.68-90.00% of peeling efficiency and this paper no have cassava tube mechanical damage [4, 6, 7, 8]. Moreover, the 2nd knife had low consumed time of about 10.3 s/tuber (Fig.8).

Fig. 9 to Fig. 11 show the cassava tuber knife peeling set. (Fig. 12) shows the remaining peels after knife peeling has been used, and flesh loss of cassava tuber caused by knife peeling. (Fig.13).

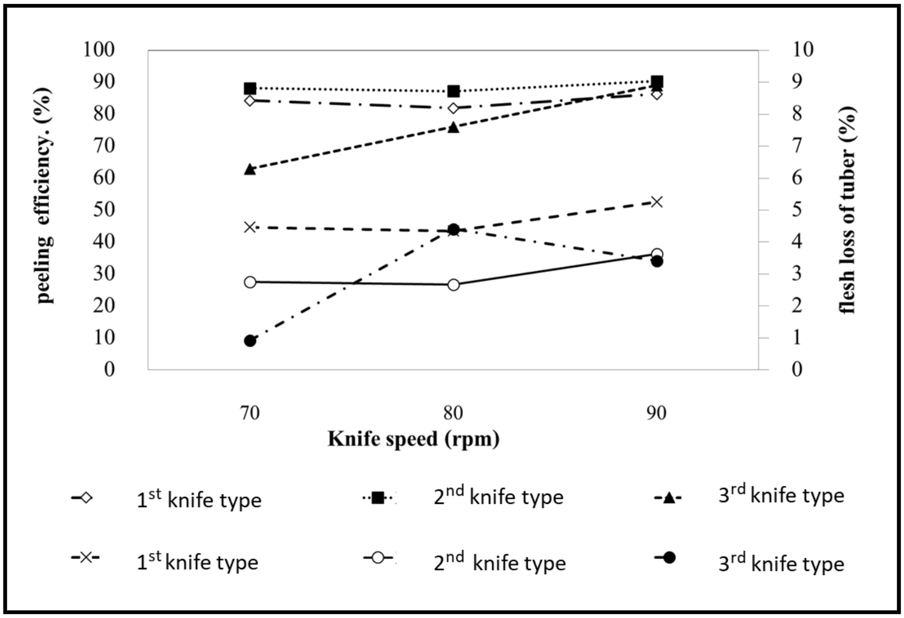

Fig. 6. Effect of knife type and knife rotating speed on peeling efficiency and flesh loss at a spring stiffness of 17.19 N/m

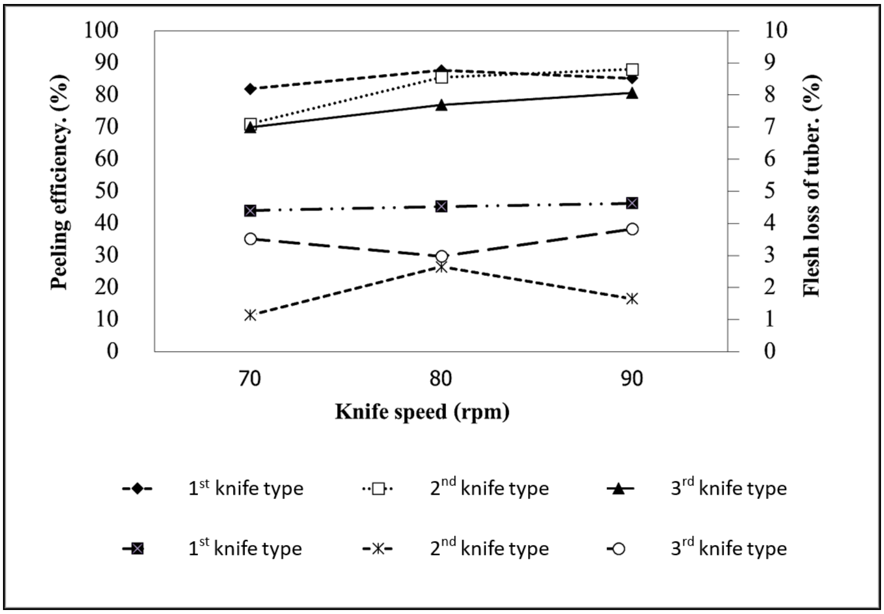

Fig. 7. Effect of knife type and knife rotating speed on peeling efficiency and flesh loss at a spring stiffness of 8.21 N/m

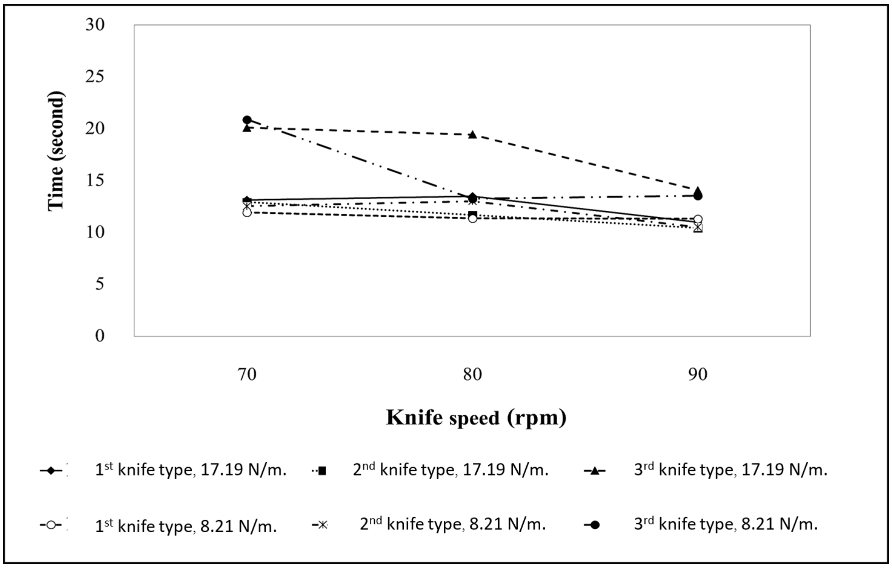

Fig. 8. Effect of knife type and knife rotating speed on peeling capacity at a spring stiffness of 17.19 and 8.21 N/m.

Fig. 9. The cassava tuber before knife peeling

Fig. 10. The cassava tuber during knife peeling

Fig. 11. Peeled cassava tuber after knife peeling

Fig. 12. Remaining peels after knife peeling

Fig. 13. Flesh loss of cassava

4. Conclusion

For the construction of a cassava tuber knife peeling unit, the 2nd knife type had high throughput capacity of 10.43 seconds per tuber and peeling efficiency of 90.3 %, while flesh loss was 3.36 % at the knife rotating speed of 90 rpm and spring stiffness of 17.19 N/m. Hence, peeling efficiency (%P.E.) and flesh loss (%F.L.) increased with increased knife rotating speed. However, the cassava tuber knife peeling unit size is restricted specifically at 30 - 60 mm diameter with average 200 mm length of cassava to facilitate peeling, the design and construction of a cassava tuber knife peeling unit can't be used to peel all sizes of cassava. In the next stage of the design, the knife peeling unit to accommodate different sizes of cassava will be introduced in order to handle the peeling of all sizes of cassava tubers.

5. Acknowledgement

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6. Reference

[1] Land Development Department, Ministry of Agriculture and Cooperatives. Cassava. Available:http://www.oae.go.th/ewt_news.php?nid=23051&filename=index, 3 march 2016.(in thai)

[2] FAO, Storage and Processing of Roots and Tubers in the Tropics, Agriculture and Consumer Production. Available: http://www.fao.org/3/x5415e/x5415e00.htm, 20 February 2018.

[3] T.W. Thiwawannawong, and T.Y. Nuboon, “The Development and Evaluation of a Peeling MachineforCassava”.Available:http://www.pht net.org/download/phticseminar/497.pdf,3march 2016.(in thai)

[4] A. M. A., Oluwole O. O., "Design and Construction of a Batch Cassava Peeling Machine," Journal of Mechanical Engineering and Automation, vol. 3, no. 1, pp. 1621, 2013.

[5] TK Jinyemiema, AC Igboanugo and GO Ariavie. Investigation of cassava tuber physical characteristics and their relationship. Academia Journal of Agricultural Research. 5(6): 137-147, 2017.

[6] C. Nathan, J. Wadal and I.U. Haruna. Comparative analysis of type 3 an type 4 cassava peeling machine. Nigerian Journal of Technology. Vol. 36, No.4: 1088-1094. 2017

[7] E. Patrick, E. Henry and U. Samuel. Design and testing of an experimental cassava tube peeling machine. International journal of Engineering Research in Africa. Vol.9, 35-42, 2013.

[8] A. D. Ilesanmi, O. A. Adefeemi, M.A. Temitayo, M.D. Oluwatosin and O.O. Ayomide. Optimization of peeling time and operational speed for cassava peeling using central composite design and response surface methodology. International Journal of Engineering Science and Research Technology. DOI: 10.5281/zenod.155086: 630-639. 2016.