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*Original Research Article*

# Some Physical Properties of Pineapple Leaves for Chopping Machine

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**Abstract:** The production of pineapple residue is increasing in line with pineapple production in Malaysia. In order to overcome this issue, a conceptual design of a harvesting and chopping machine will be developed to process the pineapple leaves. The combined chopper is vital for the current manual handling method, such as left on the ground until the next plantation or burnt. This new machine will be introduced to harvest and chop the pineapple leaves into smaller sizes. This chopper machine will comprise a specialized blade to cut the pineapple leaves with a rotating conveyor to collect the harvested leaves before chopping into the selected size. In this study, the average length and width of the three most popular cultivars in Malaysia, such as MD2 (V1), Josapine (V2), and Nanas Madu Kaca (A 11) (V3), were recorded. There are about 10 different samples collected from different plants for each variety. The results indicated that the average length and width of MD2 pineapple leaves were 742.00 mm and 58.00 mm, respectively. The average length and width of Josapine pineapple leaves were 685.50 mm and 56.70 mm, respectively. The average length and width of Nanas Madu Kaca (A 11) pineapple leaves were 817.75 mm and 56 mm, respectively. These physical characteristics of pineapple leaves are essential in designing the chopper machine for pineapple leaves after the harvesting process.

**Keywords:** pineapple leaves; chopping machine; physical properties

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## 1. Introduction

The pineapple plant, or the scientific name is '*Ananas comosus* L.,' is a perennial plant from the 'Bromeliaceae' family (Figure 1). It is a tropical fruit with vibrant flavour and ready-to-eat fruit (Hossain, 2016). The pineapple plant is a drought-tolerant perennial herb with waxy leaves and short stems. Pineapple fruit is a mixed fruit formed by the fusion of many small fruits. These small fleshy fruit fuse together around a fibrous central stem called the core. Each fruit grows on the pedicel, which is an extension of the pineapple plant stem. The fruits vary in size, and the pulp of the fruit is juicy, has an exotic sweetness, and can be light cream to yellow. The top of the fruit is called the crown. It is an extension of the root tip meristem and can be used as planting material. It was originally from Brazil and Paraguay in the Amazon basin, where the fruit was domesticated (Medina & Gracia, 2005). There are almost a hundred varieties, but the common extensively grown ones are Smooth Cayenne, Queen in the past decade (FAO, 2013).

A new variety named MD2 is introduced, which commands 80% of the global trade in pineapples (Hidayah & Fazleen, 2019). In Malaysia, the pineapple plantation industry is under the Malaysian Pineapple Industry Board (MPIB). They are responsible for managing the development and production of pineapples for domestic and international markets. There are few main types of Malaysian cultivars planted in Peninsular and Borneo of Malaysia, such as in Johor (8,112 Ha), Sarawak (1,767 Ha), and Sabah (972 Ha) (Shah, 2020).

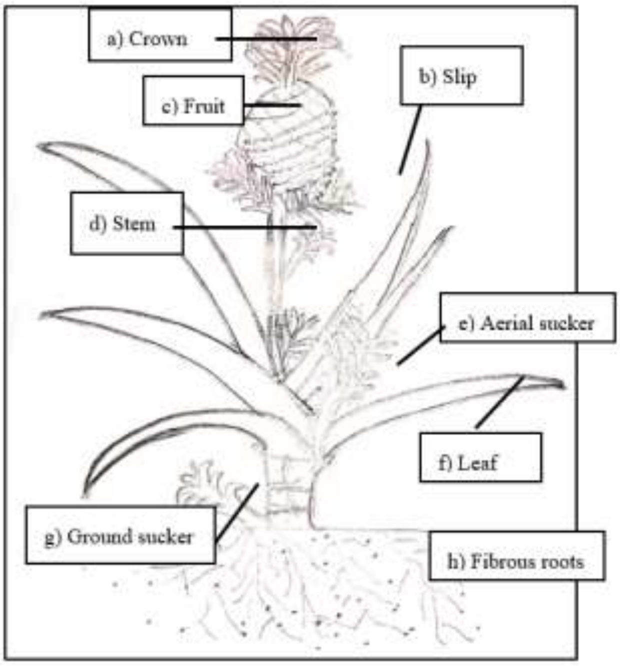



**Figure 1.** Pineapple plant structure: a) crown; b) slip; c) fruit; d) stem; e) aerial sucker; f) leaf; g) ground sucker, and h) fibrous roots.

World pineapple production was approximately 51 million tons in 2016 (Pandit *et al.*, 2020). Pineapple agriculture cultivation produced large amounts of leaves beside fruits. After harvesting the fruits, leaf bunches are cut manually using the sharp sickle. Freshly harvested green leaf bundles are used for fiber extraction. The worldwide area under pineapple harvest in 2017 was 1,098,705 Ha which can supply approximately 40 ton/h usable fresh leaves (Pandit *et al.*, 2020). Ritthisorn *et al.* (2016) stated that Thailand has 75 pineapple processing companies that generate approximately 200 tons of pineapple waste per day. However, at present, the pineapple leaves, which considered primarily as agriculture waste, might be utilized for fibres extraction from fresh leaves for making ropes, twines, composites and clothing, animal feed, and other commercialized products (Pandit *et al.*, 2020; Buliah *et al.*, 2019; Aizi, 2020). The pineapple plant is largely used as a source of fibre in the Philippines, Taiwan, and India. With the current interest in natural fibres from pineapple leaves, improved harvesting technologies are undoubtedly vital in the coming decades. Most developed technologies or machines are specifically designed to process pineapple leaves fiber (PALF), pineapple leaf paper, and dairy cow pellets (Yusri *et al.*, 2015; Pandit *et al.*, 2020; Buliah *et al.*, 2019; Azan *et al.*, 2020). However, no research has been developed on the harvesting and chopping of pineapple leaves at the plantation field. The existing machines used by farmers are not designed according to the pineapple leaves characteristics, but they are commonly used to chop palm oil and/or forage for animal feeds frond (Bulan *et al.*, 2015; Bulan *et al.*, 2017; Sreenivas *et al.*, 2017). Due to these problems, it is necessary to develop a new machine suitable to utilize the pineapple leaves on-site that could be economical, appropriate, and affordable.

## 2. Materials and Methods

Three different pineapple leaves from the MD2 (V1), Josapine (V2), and Nanas Madu Kaca (A 11) (V3) were obtained from a plantation area in Kampung Talang, Kadok, Kelantan (6°00'04.1"N 102°13'56.2"E) (Figure 2). The pineapples were planted in 9.7 Hectares. According to Mat Kasim (Personal communication, 2020), the pineapple was planted in a row according to its cultivar. Each pineapple plant usually has 40-45 stiff leaves with an average weight of about 0.065 Kg and 3% fiber per leaf. The weight of pineapple leaves was recorded using the weighing scale. The plant can grow up to a height of 75 cm to 150 cm with an expanse of 90 to 120 cm. After harvesting activities, the pineapple leaves were cut manually using a sickle.

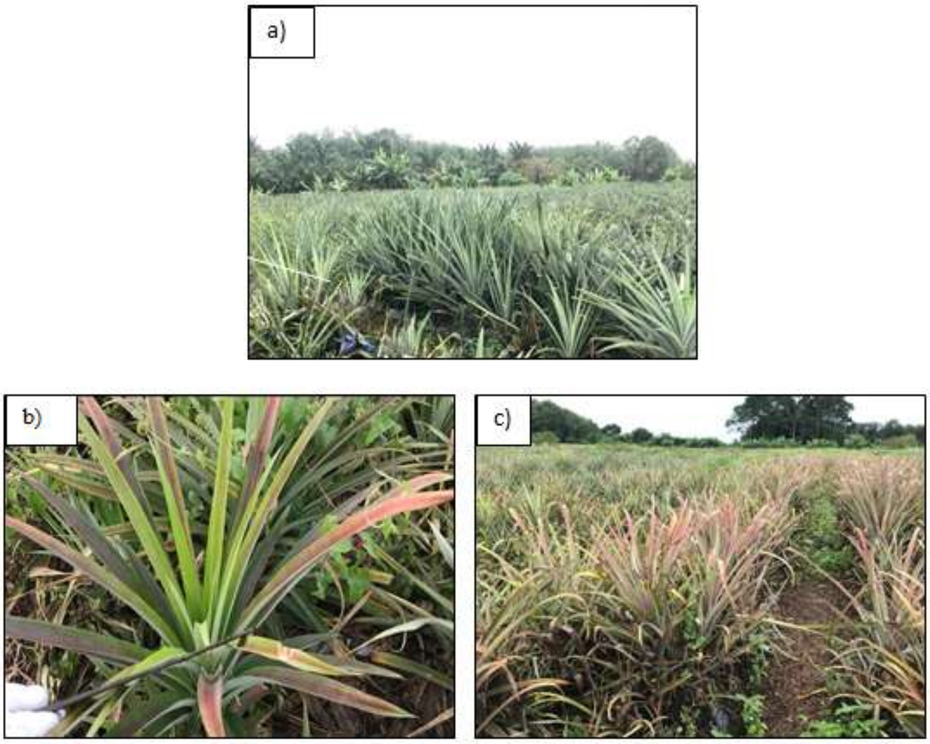



**Figure 2**. Pineapple plantation site at Kampung Talang, Kadok, Kelantan: a) Diagram of pineapple leaves; b) Pineapple leaves for MD2 cultivar (V1); c) Close up for Nanas Madu Kaca cultivar (V3); d) Pineapple leaves for Josapine cultivar (V2).

### *2.1 Size and Weight of the Pineapple Leaves*

Samples were selected at ten different locations randomly to determine the size of the leaves, the length, and the width of the pineapple leaves. The measurement of the leaves from each variety was recorded from 10 different plants, and the average values are reported. All the pineapple leaves were cut at the bottom of the leaves near the stem. The length and the width of the leaves from each variety were measured using a measuring tape by keeping the leaves in their most stable position, and the data was recorded. The length and the width of the leaves were recorded at three different sections of the whole leaves, i.e., top (D1), middle (D2), and bottom (D3) section (Figure 3).

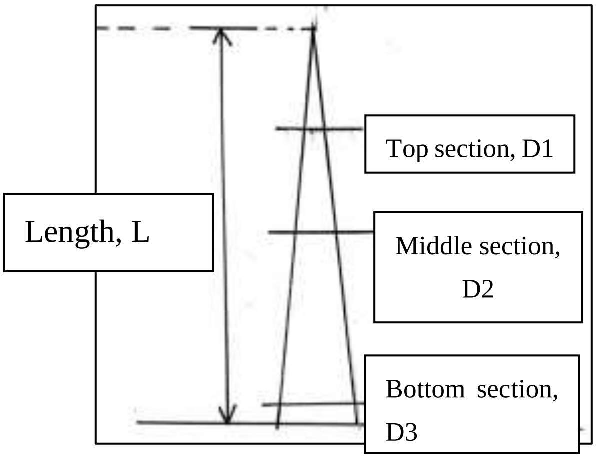



**Figure 3.** Longitudinal section of pineapple leaves.

## 3. Results and Discussions

### *3.1. Physical Observations on the Pineapple Leaves*

From the morphological observation, all three types of pineapple leaves have different characterization according to their varieties. V1 leaves are giant than the V2 and V3 variety. The V1 leaves have no thorns as compared to the V2 and V3 variety. V1 also leaves much longer and bigger in size compared to V2 and V3 variety. For the V2 variety, the size of the leaves is smaller than the V1. It is are usually sharp-pointed and needle-like in form. The leaves also have many thorns at both sides of leaves compared to V1 and V3. V2 has many thorns from the bottom section until the top section of the leaves, while V3 leaves only have thorns at the tips of the leaves only. The leaves are reddish compared to V1, where the leaves are entirely green. For the V3 variety, the size of the leaves is almost similar to the V2 variety; however, V3 leaves only have thorns at the tip of the leaves and are more tapered than V1 leaves. (Figure 2). The differences between the three types of leaves are shown in Table 1.

**Table 1**. Physical properties of V1, V2, and V3 leaves.

| | V1 | V2 | V3 |
|---|---|---|---|
| Size | Wide width with fewer pointed leaves | Needle-like | Needle-like |
| Colour | Fully green | Reddish | Reddish at the top section while greenery at the bottom section |
| Thorn | None | Full with thorns | Only have thorn at the tip section |

*3.2 Length and Width Determinations*

Table 2 shows the maximum and minimum width of the pineapple leaves, where the leaves were divided into three parts. The observed widths were recorded at the top of the leaves, in the middle, and at the end of the pineapple leaves. It is measured 5 cm from the top section and 5 cm from the bottom section. Thus, the top section for the V1 variety has the maximum and minimum observed widths between 53.00 mm and 21.00 mm, respectively. The average value for the top section was 34.80 mm. The maximum and minimum widths of the bottom section were 81.00 mm and 62.00 mm, respectively. The observed average for the bottom section was 74.60 mm. The average length and width of the leaves were 742.00 mm and 58.00 mm, respectively.

**Table 2.** The length and width of pineapple leaves, V1.

| | Maximum | Minimum | Average | Standard deviation |
|---|---|---|---|---|
| Top section, D1 (mm) | 53.00 | 21.00 | 34.80 | 9.20 |
| Middle section, D2 (mm) | 76.00 | 55.00 | 66.40 | 6.70 |
| Bottom section, D3 (mm) | 81.00 | 62.00 | 74.60 | 5.68 |
| Length, L (mm) | 860.00 | 610.00 | 742.00 | 79.97 |
| Width, (mm) | 62.00 | 53.00 | 58.00 | 2.98 |
| Weight, (kg) | 0.0066 | 0.0062 | 0.0064 | 0.0001 |

Table 3 shows the confidence interval for the length and width of pineapple leaves, V1. The recorded data for ten samples were 90% confidence interval that the sample mean lies within the interval. The length and the width of the pineapple leaves were in the interval from 695.65 mm to 788.35 mm and 56.27 mm to 59.73 mm, respectively.

**Table 3.** The confidence interval of length and width of pineapple, V1.

| | Length of pineapple leaves | Width of pineapple leaves |
|---|---|---|
| No of a sample (*n*) | 10 | 10 |
| Mean (μ) | 742 mm | 58 mm |
| Standard deviation, *s* | 79.97 | 2.98 |
| 90 % Confident interval, CI | 695.65 ± 788.35 | 56.27 ± 59.73 |

Table 4 shows the data recorded for V2; the maximum and minimum observed widths for the top section were 29.00 mm and 23.00 mm, respectively. The average value for the top section was 26.50 mm. The maximum and minimum widths of the bottom section were 58.00 mm and 48.00 mm, respectively. The observed average for the bottom section was 52.60 mm. From the data obtained, the width of the bottom section is wider than the width of the top section of the pineapple leaves. The average length and width of the leaves were 685.50 mm and 56.70 mm, respectively.

**Table 4.** The length and width of pineapple leaves, V2.

| | Maximum | Minimum | Average | Standard deviation |
|---|---|---|---|---|
| Top section, D1 (mm) | 29.00 | 23.00 | 26.50 | 2.12 |
| Middle section, D2 (mm) | 51.00 | 43.00 | 46.50 | 2.42 |
| Bottom section, D3 (mm) | 58.00 | 48.00 | 52.60 | 3.37 |
| Length, L (mm) | 750.00 | 650.00 | 685.50 | 45.00 |
| Width, (mm) | 60.00 | 54.00 | 56.70 | 2.26 |
| Weight, (kg) | 0.0061 | 0.0054 | 0.0058 | 0.0003 |

Table 5 shows the confidence interval for the length and width of pineapple leaves, V2. The recorded data for ten samples were 90% confidence interval that the sample mean lies within the interval. The length and the width of the pineapple leaves were between 659.42 mm to 788.35 mm and 43.69 mm to 46.31 mm, respectively.

**Table 5.** The confidence interval of length and width of pineapple, V2.

| | Length of pineapple leaves | Width of pineapple leaves |
|---|---|---|
| No of a sample (n) | 10 | 10 |
| Mean (μ) | 685.50 mm | 45.00 mm |
| Standard deviation, s | 45.00 | 2.26 |
| 90 % Confident interval, CI | 659.42 ± 711.58 | 43.69 ± 46.31 |

Table 6 shows the data recorded for the V3 variety. The maximum and minimum observed widths for the top section were 31.00 mm and 20.00 mm, respectively. The average value for the top section was 28.10 mm. The maximum and minimum widths of the bottom section were 55.00 mm and 46.00 mm, respectively. The observed average for the bottom section was 50.20 mm. From the data obtained, the width of the bottom section is wider than the width of the top section of the pineapple leaves. The average length and width of the leaves were 817.75 mm and 56.00 mm, respectively.

**Table 6.** The length and width of pineapple leaves, V3.

| | Maximum | Minimum | Average | Standard deviation |
|---|---|---|---|---|
| Top section, D1 (mm) | 31.00 | 20.00 | 28.10 | 3.45 |
| Middle section, D2 (mm) | 51.00 | 44.00 | 47.80 | 2.66 |
| Bottom section, D3 (mm) | 55.00 | 46.00 | 50.20 | 2.94 |
| Length, L (mm) | 930.00 | 680.00 | 817.75 | 79.56 |
| Width, (mm) | 61.00 | 51.00 | 56.00 | 3.60 |
| Weight, (kg) | 0.0062 | 0.0068 | 0.0062 | 0.0002 |

Table 7 shows the confidence interval for the length and width of pineapple leaves, V3. The recorded data for ten samples were 90% confidence interval that the sample mean lies within the interval. The length and the width of the pineapple leaves were in the interval from 771.63 mm to 863.87 mm and 53.91 mm to 58.09 mm, respectively.

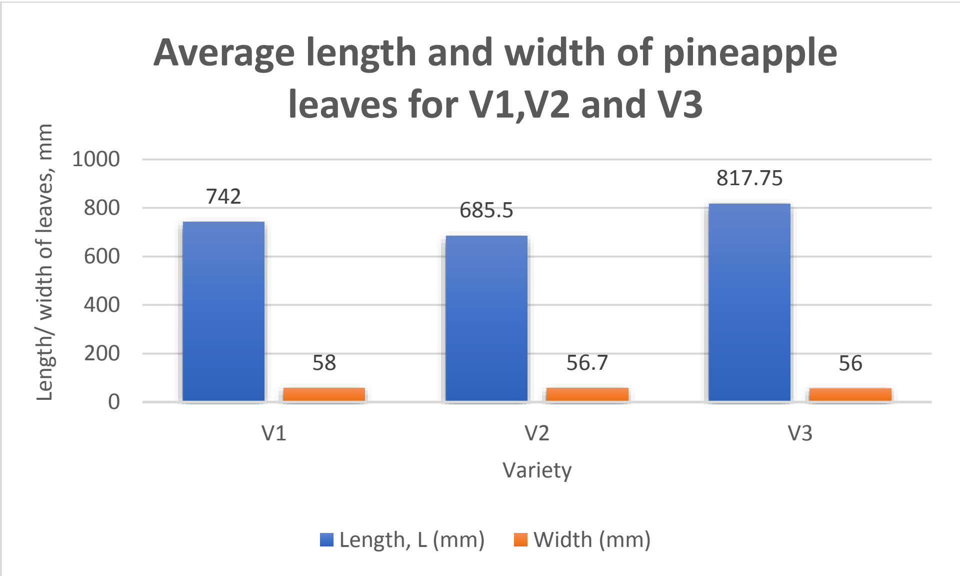
**Table 7.** The confidence interval of length and width of pineapple, V3.

| | Length of pineapple leaves | Width of pineapple leaves |
|---|---|---|
| No of a sample ($n$) | 10 | 10 |
| Mean ($\mu$) | 817.75 mm | 56.00 mm |
| Standard deviation, $s$ | 79.56 | 3.60 |
| 90 % Confident interval, CI | 771.63 ± 863.87 | 53.91 ± 58.09 |

Table 8 shows the average measurements for V1, V2, and V3 varieties. The observed length at the top section for V1, V2, and V3 were 34.80 mm, 26.50 mm, and 28.10 mm. Therefore, the length at the top section of V1 is longer compared to V2 and V3 variety. Next, the length of the middle section for V1, V2, and V3 were 66.40 mm, 46.50 mm, and 47.80 mm, respectively. The middle section of V1 is more extended than V2 and V3, but the length of V3 is longer than the V2 variety. The length of the bottom section for V1, V2, and V3 are 74.60 mm, 52.60 mm, and 50.20 mm, respectively. It is shown that V3 also has the most extended length compared to V2 and V3. The V1, V2, and V3 varieties' observed widths were 58.00 mm, 56.70 mm, and 56.00 mm, respectively. The width of V1 is wider compared to V2 and V3.

**Table 8**. The average length and width of V1, V2, and V3 pineapple leaves.

| | *V1* | *V2* | *V3* |
|---|---|---|---|
| Top section, D1 (mm) | 34.80 | 26.50 | 28.10 |
| Middle section, D2 (mm) | 66.40 | 46.50 | 47.80 |
| Bottom section, D3 (mm) | 74.60 | 52.60 | 50.20 |
| Length, L (mm) | 742.00 | 685.50 | 817.75 |
| Width (mm) | 58.00 | 56.70 | 56.00 |
| Weight, (kg) | 0.0064 | 0.0058 | 0.0062 |




**Graph 1.** The comparison between the average length and width of V1, V2, and V3 pineapple leaves.

### *3.3 Weight Determinations*

The weight of the pineapple leaves between V1, V2, and V3 was measured. The average weight of pineapple leaves for V1 is 0.0064 Kg, while V2 and V3 are 0.0058 and 0.0062 Kg, respectively. It is clearly showing that V1 has more loads compared to V2 and V3.

From the experiment, we have obtained some physical properties for three different varieties of MD2, Josapine, and Nanas Madu Kaca. The measurement data of the pineapple leaves are very useful in designing the size and force of the blade for the chopping machine.

The results from the texture analysis will be significant in determining the texture and cutting force analysis.

## 4. Conclusions

In a nutshell, the success of this project will be very beneficial to the farmers to solve the problems in managing the pineapple leaves. It can conserve the environment and improve the efficiency of the post-harvest process by replacing the manual cutting method. Inventing this new chopping machine will be economical, easy to operate, time-saving, and efficient compared to the manual system.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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