Pandan leaf powder: characteristics and its application in Pandan sponge cake making

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Abstract. The unique scent of Pandan leaves is commonly used in traditional food processing. The scent is derived from fresh leaves which become waste after being used. Following the zero-waste concept, this research aimed to convert Pandan leaves into a powder so that it can be fully utilised. This research specifically characterised the Pandan’s powder from various means of drying and obtained the preferred concentration for the making of Pandan sponge cake. The powder was made by using Fresh Pandan leaves that were dried at 40 and 50°C in cabinet dryer, vacuum oven and freeze dryer. The dried leaves were then processed into a powder. The Pandan powder with concentrations of 2.5, 5.0, and 7.5% was added to the Pandan sponge cake formulation. The powder contained 7.9-10.65% moisture, 70.05-161.63 mg/L total chlorophyll and 17.69-23.46% fibre. The best treatment was obtained from Pandan sponge cake with the addition of 2.5% Pandan leaf powder which dried in the cabinet dryer at 40°C for 6 h. The Pandan sponge cake contained 60.30% carbohydrate, 12.73% protein, 5.28% fat, 20.24% water, 1.45% ash, 0.032% sodium and 6.38% crude fibre. The Pandan sponge cake showed pore size of 0.022 mm², hardness of 603.2 g, cohesiveness of 0.47, springiness of 6.37 mm, with organoleptic score of aroma and colour 5.71 and 5.65 (out of 7). Pandan leaf in powder form is potential to be developed as a food ingredient, because it still provides aroma, contains chlorophyll and fibre, and complies with zero waste concept.

1. Introduction
Indonesia is a tropical country that is endowed with a variety of flora that is useful, one of which is a Pandanus plant (Pandanus amaryllifolius Roxb). Pandan has been used traditional in Indonesia because it has long been used primarily to provide a pleasant aroma/fragrance to a variety of food preparations. At the global level, Pandan is a hot topic in the food world community since it is one of the top trends in food and drink 2018 [1].

Pandan leaves have a distinctive aroma, one of which is due to the chemical component in the form of 2-Acetyl-1-Pyrroline (ACPY) [2,3]. The ACPY is hydrophilic which can be easily dissolve in water or alcohol, and the aroma can still be detected at concentrations as low as 0.01ppm in water [2]. It was further said that the scent of Pandan was pungent and could cover up other scents. The ACPY gives a distinctive aroma like the aroma of rice (basmati). Jiang identified 22 Pandan scent-forming components, consisting of 9 alcohols, 4 carboxylic acids, 3 ketones, 2 esters, 3 hydrocarbons and 1 furanone. The main component is 3-methyl-2 (5H) -furanone which makes up 73% of the total volatile component. Other main components are 3-hexanol, 4-methyl-2-pentanol, 3 hexanone and 2-hexanone with a range of 2.65-7.09% [4].
The distinctive aroma makes Pandan is widely applied in various dishes, not only in Indonesia but also in Southeast Asia such as Malaysia and Thailand. Pandan leaf called ‘vanilla of the East’ and has the potential to be used as a natural food ingredient to provide a better aroma to sweet or savoury foods and is sought after by consumers [3]. Pandan leaves are widely used in rice-based dishes, chicken, jelly, drinks, pudding, or other sweet foods.

The application of Pandan leaves in food is limited to the utilisation of its scent, either from fresh or the leaves extract. These methods made the dried leaves as waste. Meanwhile, Pandan leaves like other green leaves contain chlorophyll, fibre and minerals that are beneficial. Therefore, in this study Pandan leaves were made into powder using various drying processes, and then applied to a Pandan sponge cake product.

The strongest aroma of Pandan is found on the fresh leaves, but the period of the freshness of Pandan leaves is about 1-2 days after harvesting. Fresh Pandan is also difficult to be found in urban areas. Thus, the dried and powdered Pandan leaves can solve this limitation. The drying process can reduce the aroma of Pandan leaves. Therefore, in the present research, various means of drying were studied to produce Pandan leaf powder which still contains an acceptable aroma.

2. Materials and Method

Materials used in pandan powder were fresh Pandan leaf obtained in Malang Regency with specifications of green colour, has leaf length of 29 ± 1 cm and a leaf width of 4 ± 1 cm; and maltodextrin. Ingredients used in making Pandan sponge cake were wheat flour (Segitiga Biru), sugar (Gulaku), eggs, full cream milk powder (Indomilk), margarine (Blueband), bread improver SP (koepoe-koepoe), maltodextrin and baking powder (koepoe-koepoe).

The study consisted of two stages. The first stage was making the pandan powder, which was prepared using a Completely Randomized Design (CRD) with 7 drying treatments (1) cabinet drying at 40°C for 6 h, (2) cabinet drying at 50°C for 5 h, (3) vacuum drying at 40°C for 6 h, (4) vacuum drying at 50°C for 5 h, (5) pandan leaves were crushed with a blender, and 3% maltodextrin was added and then dried at 40°C in a vacuum dryer for 6 h, (6) pandan leaves were crushed with a blender and were added 3% maltodextrin then dried at 50°C in vacuum dryer for 5 h, and (7) freeze-drying at -75°C for 18 h. The experiments were repeated 3 times. The dry Pandan was then ground and sieved at 100 mesh. The Pandan powder was then analysed for water content [5], fibre content [5], total chlorophyll [6].

The second stage of the research was the application of the powder in Pandan sponge cake making. The study was prepared by using 2 factors randomized block design. The Factor I was the Pandan powder from various drying (7 drying means in stage 1), and factor II was the proportion of Pandan leaf powder (2.5, 5 and 7.5%).

The formulation for making Pandan cake used was 50g of total flour (flour: Pandan powder ratio were 47.5: 2.5, 45: 5, and 42.5: 7.5), 50g sugar, 60 ml egg, 30g margarine, 4g SP, 2g baking powder, 10g full cream milk powder, 30g and water. Sugar, SP and margarine ingredients were mixed at medium speed for 5 min. The eggs were added, and mixed at medium speed for 10 min, water was then added and the mixing was continued at low speed for 2 min. Dry ingredients such as flour, Pandan powder, milk and baking powder were added and stirred at low speed for 5 min. The batter was put into a baking pan and baked in an oven at 170°C for 40 min.

The Pandan sponge cake was then analysed including colour, expanding the volume, pore (with ImageJ application (https://imagej.nih.gov/ij/) and texture which was measured with CT3 Texture Analyzer (Brookfield Enginering Labs Inc., USA) using probes cylindrical diameter 38.1 mm (TA4 / 1000). The Pandan sponge cake was pressed as deep as 5 mm at a speed of 1 mm/s, the measured data including hardness, springiness and cohesiveness. Organoleptic parameters analysed including colour, aroma, taste, texture and pore.

The data were analysed by ANOVA and Tukey’s HSD test with α=0.05. The existing data was used to obtain the best treatment with the Zeleny test. The best Pandan sponge cake moisture content of the oven method, starch, fat, protein, crude fibre, ash, and carbohydrate (by different) was then analysed by the AOAC method [5] and sodium content with Atomic Absorbtion Spectrophotometer (AAS).
3. Results and Discussion

3.1. Characteristics of fresh Pandan leaves

Physical characteristics analysed were colour intensity (L *, a *, b *), while the chemical characteristics analysed included moisture content, fibre content and total chlorophyll.

Table 1 shows the colour Lab of fresh Pandan leaves. Fresh Pandan leaves have a green to yellowish-green colour. The green colour is caused by the chlorophyll content, while the yellowish-green colour is caused by carotenoid and xanthophyll content. Carotenoid components of pandan are neoxanthin, violaxanthin, α-carotene, β-carotene, lutein, zeaxanthin and vitamin E [8].

| Parameter                  | Present research        | Literature [7]    |
|----------------------------|-------------------------|-------------------|
| Colour L; a; b             | 43.88±0.58; -8.68±0.54; +11.66±0.53 | -                  |
| Total chlorophyll (mg/L)   | 24.66±1.98              |                   |
| Water (%)                  | 84.32±0.61              | 80%               |
| Fibre (%)                  | 3.42±0.65               | 3.5%              |

Notes: Means of 3 repetitions ± standard error.

The total chlorophyll content in fresh Pandan leaves was 24.66 mg/L. The chlorophyll molecule has a nucleus of Mg²⁺ which causes chlorophyll to be ionic and hydrophilic, and a hydrophobic ring with a carbonyl group tail makes it polar [9]. There are two chlorophyll, a and b. Chlorophyll-b is more soluble in polar solvents than chlorophyll-a because it has a carbonyl group. According to [10] because of the high chlorophyll content, Pandan leaves are also widely used as food green colouring.

Fresh Pandan leaves contain 84.32% water, have the potential to be easily damaged and do not have a long shelf life. Water is part of the protoplasm which makes up 85-90% of the total weight in plant tissue and functions as a solvent of salt, gas and other substances that are transported to tissue cells, as well as maintaining cell growth and maintain the stability of the leaf shape [11]. The presence of water affects the total chlorophyll, where chlorophyll increases with increasing stress levels in the leaves. The lower the water content, the stress level of the leaf will tend to be high so that the total chlorophyll produced will be lower [12].

The crude fibre in fresh Pandan leaves was 3.42%. This is exciting for further investigation considering the fibre is useful for digestion. World Health Organization (WHO) recommends consuming 25g of fibre per day for optimal health.

3.2. Characteristic of Pandan leaf powder

The colour of powdered Pandan leaves ranged from L 52.74 to 57.27, the a values were between -8.10 and -11.16 and the b values were between 20.04 and 24.10 (Table 2). The drying method has a significant effect (α = 0.05) on the L and b colour of Pandan leaves powder.

| Drying methods            | Colour L   | a          | b          |
|---------------------------|------------|------------|------------|
| Cabinet dryer 40°C, 6 h   | 55.00±0.13 | -9.14±0.28 | 23.10±0.61 |
| Cabinet dryer 50°C, 6 h   | 56.03±0.20 | -10.31±1.20| 20.04±1.00 |
| Vacuum dryer 40°C, 6 h    | 57.27±0.73 | -9.13±0.24 | 21.63±0.60 |
| Vacuum dryer 50°C, 6 h    | 52.74±0.99 | -11.16±0.99| 23.69±1.11 |

Notes: Means of 3 repetitions ± standard error. The same symbol shows the insignificant different on Tukey’s HSD test α=0.05.

Lab values showed that the greenest of leaf powder colour was obtained from the freeze-drying method, and the least green colour was obtained from the vacuum drying at 50°C with the addition of
maltodextrin. The higher the drying temperature, the higher the brightness value. The heat on drying caused the colour of Pandan powder fading. According to Wongpornchai [8] the heating temperature, pH and heating time during the drying process have a considerable influence on the aroma and colour of the leaves produced. Drying using a freeze dryer can keep the chlorophyll component so that the powder has a dark green colour. Addition of fillers such as maltodextrin reduced the green colour.

Table 3 shows that the highest total chlorophyll was found in the drying treatment using a cabinet dryer at 40°C. While the lowest total chlorophyll was found in the treatment with the addition of maltodextrin which then dried using vacuum dryer at 50°C. The presence of 3% maltodextrin reduced the proportion of Pandan. Maltodextrin increased the number of solids and did not contain chlorophyll, thereby reducing the proportion of chlorophyll.

Table 3. Average total chlorophyll (mg/L), moisture content (%) and fibre (%) of Pandan leaf powder in various drying methods

| Drying methods               | Total chlorophyll (mg/L) | Moisture content (%) | Fibre (%) |
|------------------------------|--------------------------|----------------------|-----------|
| Cabinet dryer 40°C, 6 h      | 161.63±8.11              | 8.47±1.05            | 19.84±0.60 |
| Cabinet dryer 50°C, 6 h      | 141.93±10.89             | 7.89±0.29            | 22.37±3.90 |
| Vacuum dryer 40°C, 6 h       | 124.03±10.93             | 7.84±0.24            | 20.54±2.02 |
| Vacuum dryer 50°C, 6 h       | 115.05±7.28              | 7.63±0.33            | 23.46±1.32 |
| Vacuum dryer 40°C, 6 h +3% maltodextrin | 89.49±8.52           | 7.28±0.48            | 17.69±0.82 |
| Vacuum dryer 50°C, 6 h +3% maltodextrin | 70.05±2.20          | 7.09±0.12            | 18.65±0.78 |
| Freeze dryer - 75°C, 18 h   | 113.05±10.18             | 10.65±0.48           | 20.42±2.60 |

Notes: Means of 3 repetitions ± standard error. The same symbol shows the insignificant different on Tukey’s HSD test α=0.05

The water content of the Pandan leaves produced from the cabinet and vacuum dryers were similar, but different when it dried with a freeze dryer (Table 3). The higher the drying temperature, the lower the water content. Freeze-drying had the highest moisture content, and the advantage of the freeze-drying method produces hollow products with high rehydration power [13].

The crude fibre content of Pandan leaves increased sharply from 3.42 to 17.69-25.37% from fresh to powder, due to the decrease in water from 84.32% to 7.28-10.65%. The lowest crude fibre content was obtained from the drying under vacuum dryer at 40°C for 6 h with the addition of 3% maltodextrin. The addition of maltodextrin increased the amount of solid but reduced the amount of crude fibre.

3.3. Physical characteristics of Pandan sponge

Table 4 shows that the pore size of Pandan sponge cake ranges from 0.022 to 0.636 mm². The pore size was not significantly affected by drying methods and proportions of Pandan powder added. Pores were air holes or cells contained in bread and were developed during the fermentation and baking process. Pore quality was controlled by mixing variation and mixing time [14]. The formation of pores in the Pandan sponge cake was started when the air entering the dough during mixing and the formation of CO₂ gas.

The texture profile of Pandan sponge cake (hardness, cohesiveness and springiness) was influenced by the drying method, and the proportion of Pandan leaf powder added. The hardness of Pandan sponge cake was between 268.20 g to 541.80 g. In the treatment of vacuum dryer + maltodextrin 3% at 50°C dried for 5 h showed that the addition of 7.5g Pandan powder had the highest hardness, whereas, in the treatment of cabinet dryer at 40°C for 6 h, the addition of 2.5% Pandan powder had the lowest hardness. It is suspected that the higher addition of Pandan powder increased the hardness of the sponge dough due to the high fibre contained in the powder. Hardness is influenced by the addition of high fibre material which causes increased product hardness [15].
The cohesiveness of the Pandan sponges was between 5.6 to 8.5. The highest cohesiveness was found in the addition of Pandan powder of 5% which dried in the vacuum at 50°C for 5 h. The lowest cohesiveness was found in the addition of 7.5% Pandan powder which dried in the cabinet dryer at 40°C for 6 h. This was due to the cohesiveness depends on the water content of the material. The higher the water content, the higher the cohesiveness value [16]. Other factors that influence the cohesiveness value were the proportion of the addition of non-gluten material such as powdered Pandan leaves. The more non-gluten material added, the cohesiveness value decreases because the structure is too hard, so the texture will be damaged when given compression [17].

The springiness in the Pandan sponge cake was between 0.35 mm to 0.78 mm. The highest springiness was from the treatment of vacuum drying + maltodextrin 3% at 50°C dried for 5 h with the Pandan powder proportion of 2.5%. The lowest springiness was from the treatment in the vacuum drying at 50°C dried for 5 h with the Pandan powder proportion of 5%. An increase in Pandan leaf powder addition reduced the springiness. This is due to the compression on the product that could damage the product structure due to the high level of hardness, resulting in the texture cannot return to its original position [17].

The colour of the Pandan sponge cake produced was influenced by the drying method, and the concentration of Pandan powder added, as shown in Table 5. The greenest Pandan sponge cake was obtained from the addition of Pandan powder dried with cabinet dryer at 50°C for 6 h. The colour of Pandan sponge cake was greener with the higher concentration of Pandan powder added (Lab for 2.5% added pandan powder is 47.68; 5.41 and 16.91 compared to 43.51; 6.32; 13.85 for 5.0%; and 42.01; 8.36; 10.88 for 7.5%). However, the crust colour was brown. Brownish crust colour occurred when the temperature of the sponge was more than 110°C [18]. Browning crust colour occurred when the amount of water [14]. The raw material of sponge with high water content produced a shiny crust.

### Table 4. Pore size and texture profile of Pandan sponge cake at various levels of Pandan leaf powder

| Drying means | Pandan powder (%) | Pore size (mm²) | Hardness (g) | Cohesiveness (g) | Springiness (mm) |
|--------------|-------------------|----------------|--------------|-----------------|-----------------|
| CD 40°C, 6h  | 2.5               | 0.02±0.01      | 0.6±0.13     | 6.5±0.19        | 0.6±0.13        |
|              | 5.0               | 0.037±0.01     | 0.4±0.34     | 7.4±0.37        | 0.4±0.34        |
|              | 7.5               | 0.040±0.03     | 0.5±0.20     | 5.6±0.47        | 0.5±0.20        |
| CD 50°C, 6h  | 2.5               | 0.068±0.02     | 0.4±0.14     | 7.2±0.29        | 0.4±0.14        |
|              | 5.0               | 0.080±0.02     | 0.8±0.08     | 7.4±0.46        | 0.8±0.08        |
|              | 7.5               | 0.054±0.01     | 0.7±0.14     | 7.3±0.38        | 0.7±0.14        |
| VD 40°C, 6h  | 2.5               | 0.055±0.01     | 0.5±0.00     | 7.9±0.12        | 0.5±0.00        |
|              | 5.0               | 0.057±0.02     | 0.3±0.29     | 7.3±0.50        | 0.3±0.29        |
|              | 7.5               | 0.027±0.01     | 0.5±0.00     | 7.8±0.97        | 0.5±0.00        |
| VD 50°C, 6h  | 2.5               | 0.049±0.03     | 0.3±0.00     | 8.1±0.49        | 0.3±0.00        |
|              | 5.0               | 0.033±0.01     | 0.4±0.00     | 8.5±0.14        | 0.4±0.00        |
|              | 7.5               | 0.039±0.02     | 0.6±0.12     | 7.0±0.32        | 0.6±0.12        |
| VD 40°C,     | 2.5               | 0.031±0.02     | 0.4±0.23     | 7.5±0.65        | 0.4±0.23        |
| 6h, 3%MD     | 5.0               | 0.047±0.03     | 0.6±0.12     | 8.3±0.71        | 0.6±0.12        |
|              | 7.5               | 0.059±0.04     | 0.6±0.14     | 6.3±1.11        | 0.6±0.14        |
| VD 50°C,     | 2.5               | 0.054±0.05     | 0.5±0.00     | 7.4±0.60        | 0.5±0.00        |
| 6h, 3% MD    | 5.0               | 0.041±0.03     | 0.2±0.20     | 6.2±0.43        | 0.2±0.20        |
|              | 7.5               | 0.036±0.02     | 0.6±0.09     | 8.4±0.64        | 0.6±0.09        |
| FD, -75°C,   | 2.5               | 0.294±0.36     | 0.5±0.00     | 6.1±0.69        | 0.5±0.00        |
| 18h          | 5.0               | 0.303±0.18     | 0.4±0.00     | 6.6±1.09        | 0.4±0.00        |
|              | 7.5               | 0.636±0.51     | 0.3±0.00     | 7.2±0.79        | 0.3±0.00        |

Notes: Means of 3 repetition ± standard error. The same symbol shows the insignificant different on Tukey’s HSD test α=0.05. CD = Cabinet Dryer; VD = Vacuum Dryer; MD = Maltodextrin; FD = Freeze Dryer.
which will affect the gelatinization of starch in the crust. The appearance of shiny browning crust was as a result of the water being evaporated. Furthermore, the sponge will also undergo caramelisation to add colour and gloss.

Table 5. The average Lab colour of Pandan sponge cake powder with various drying method

| Drying methods                  | Colour L   | a   | b   |
|---------------------------------|------------|-----|-----|
| Cabinet dryer 40°C, 6 h         | 42.42 b    | 8.09 ab | 16.19   |
| Cabinet dryer 50°C, 6 h         | 40.77 c    | 7.46 ab | 11.79   |
| Vacuum dryer 40°C, 6 h          | 44.50 abc  | 4.73 b  | 14.36   |
| Vacuum dryer 50°C, 6 h          | 49.87 a    | 4.41 b  | 13.79   |
| Vacuum dryer 40°C, 6 h +3% maltodextrin | 41.92 bc       | 13.76 a | 14.18   |
| Vacuum dryer 50°C, 6 h +3% maltodextrin | 48.39 ab  | 4.64 b  | 10.90   |
| Freeze dryer -75°C, 18 h        | 42.97 bc   | 3.79 b  | 15.97   |

Notes: Means of 3 repetitions ± standard error, the same symbol shows the insignificant different on Tukey’s HSD test α=0.05

3.4. The best treatment of the Pandan sponge cake
The selection of best Pandan sponge cake was made using Zeleny’s Multiple Attribute method based on the colour parameters, aroma, taste, pores, texture, acceptability, hardness, springiness, cohesiveness, and Lab colour values. The best treatment was the Pandan sponge cake with addition of 2.5% Pandan powder that dried in the cabinet dryer at 40°C for 6 h. In general, the best Pandan sponge cake had a rating between mild to moderate, and the panellists accept the quality, with organoleptic scores (in range value from 1 (dislike) to 7 (like)) were 5.65 (colour), 5.71 (aroma), 6.23 (flavour), 5.40 (pore), 5.33 (texture) and 5.93 (overall score). The chemical analysis of Pandan cake can be seen in Table 6.

Table 6. Chemical characteristic of the best pandan sponge per 100 g

| Parameter         | Best Pandan sponge cake | Sponge cake commercial [19] |
|-------------------|-------------------------|-----------------------------|
| Carbohydrate (%)  | 60.30                   | 61                          |
| Protein (%)       | 12.73                   | 5.4                         |
| Water (%)         | 20.24                   | 29.7                        |
| Fat (%)           | 5.28                    | 2.7                         |
| Ash (%)           | 1.45                    | 0.52                        |
| Sodium (%)        | 0.032                   | 0.134                       |

Note: cake, sponge, commercially prepared FDC ID 172706 [19]

Table 6 shows that carbohydrate, ash and sodium parameters of the best pandan sponge cake are comparable to the commercial one [19]. However, pandan sponge cake contains more protein and fat content may be caused by the lesser moisture content, and also due to addition of source of protein such as chicken egg and fatty ingredients such as full milk and margarine in formulation.

4. Conclusions
The different types of dryers used in the present study on the making of Pandan leaves powder gave significant effects on the powder characteristics. The effect was on the brightness value (L *), yellowish value (b *), total chlorophyll, and the characteristics of the redness value (a *). However, the type of dryer did not have a significant effect on water content and fibre content. In making Pandan sponge, the addition of powdered Pandan leaves has a significant effect (α = 0.05) on the physical characteristics of the swelling volume, hardness, cohesiveness, elasticity and brightness value (L *). However, the various
concentration of Pandan powder did not affect the pore size, redness value (a *), and yellowish value (b *). Based on the physical and organoleptic characteristics, the best treatment was the treatment with the addition of 2.5% Pandan leaves powder which dried in the cabinet dryer at 40°C for 6 h. The best treatment has a carbohydrate content of 60.30%, 12.73% protein, 20.24% water, 5.28% fat, 1.45% ash, 0.032% sodium.

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