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Quality retention of microwave dried pineapple peels and core

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Abstract

Pineapple wastes such as peels and core contain many nutritional values and can be utilised for many purposes. Thus, this work aims to study the drying characteristics and quality of pineapple peels and core in microwave drying. The pineapple peels and core were dried under different microwave power (180 W, 450 W, and 850 W). The total phenolic content (expressed as gallic acid equivalent GAE) and antioxidant activity of microwave dried peels and core were analysed. The findings show higher microwave power led to shorter drying time, thus resulting to high drying rate. For the quality analysis, dried peels and core retained significant amount of total phenolic content. Dried peels and core had 19.8 mg GAE/g dry sample and 21.3 mg GAE/g dry sample, for drying at power level of 180 W and 800 W, respectively. Furthermore, dried peels and core were also found to retain significant antioxidant activity. Dried pineapple core at 180 W achieved around 74% DPPH inhibition which shows high antioxidant activity was still available. In conclusion, microwave drying retains significant quality of dried pineapple peels and core and has potential as alternative for preservation of fruits.

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1.0 Introduction

Malaysia is a country with vibrant tropical climate where year-long heat and abundant rainfall permit a wide variety of delicious fruits to flourish. Pineapple or *Ananas comosus* is one of the familiar fruits among citizens in Malaysia and the world especially in the country of Costa Rica, Brazil, Philippine, and Thailand. Pineapple is an excellent source of vitamin A, B, and C. It also contains minerals such as calcium, manganese, iron, and phosphorus. The presence of compounds such as ascorbic acid, polyphenols, caffeic acid, flavonoids etc. contribute to the antioxidant activity in the fruit extracts.

Drying is one of the most effective techniques used to preserve food products normally fruits and vegetables. It is a process that related with the removal of small amount of water or liquid from materials. The reduction in moisture content, resulting in the inhibition of spoiled microorganism such as bacteria, mould and fungi. Apart from that, drying can avoid the deterioration of food nutrients and decrease the enzymatic activity. According to Lüle & Koyuncu (2015), drying of food products makes further process handling, transportation, and storage easier due to the volumetric shrinkage and weight losses during the drying treatment.

Properly selected drying method of the raw material may increase the quality of product. Microwave drying is one of the methods used to preserve food. Microwave is a propagation of electromagnetic energy through space by means of time-varying electric and magnetic fields (Wani & Khot, 2014). Microwave heating is specifically connected with dielectric loss of the material. When high frequency electric field is introduced, a material will absorb the energy. Subsequently, electric dipole polarisation and conduction will be created inside the dielectric material made of positive and negative polar molecules. These organised, scattered polar molecules, vibrate promptly and aggressively in response to the high frequency electric field of the microwave (Rattanadecho & Makul, 2016). Resistance to molecular attraction and motion must be overcome which in turn increasing the temperature of the material as the friction produces heat.

Microwave drying has several advantages such as high drying rate and short drying time (Moghanaki, Khoshandam & Mirhaj, 2013; Lüle & Koyuncu, 2015; Simha et al., 2016). Under microwave drying, internal heat helps increase the internal temperature and vapor pressure, then cause the liquid flow towards the surface, resulting in increasing the drying rate and shorten the time as well as improved the quality of the product (Seremet et al., 2016). Other advantages include instantaneous and precise electronic control, deep penetration of microwave energy that allows heat to be generated efficiently, and clean heating processes that do not generate secondary waste (Rattanadecho & Makul, 2016).

Previous studies revealed that microwave application can improve product qualities such as aroma, phenolic compound, and antioxidant activity due to the disruption of cell wall (Inchuen et al., 2010; Izli, 2016). The quality of dried product strongly depends on the conditions of the drying process. It is of interest to investigate the effect of microwave properties on the quality of the pineapple wastes (core and peels) especially the beneficial phenolic compound and antioxidant activity of the dried pineapple wastes.

Microwave drying has been proven to be suitable for retention of ascorbic acid and other bioactive compounds in agricultural products such as in banana (Maskan, 2000), potato (Khraisheh et al., 2004), broccoli (Zhang and Hamauzu, 2004), apricots (Karatas and Kamisli, 2007), corn (Gursoy et al., 2013), and orange peels (Talens et al., 2016). Thus, the objective of the present study is to evaluate the effect of microwave power on the drying characteristics and quality of dried pineapple wastes.

2.0 Methodology

2.1 Materials

Fresh Josephine pineapple (*Ananas comosus L)* fruits were purchased from local market in Shah Alam. The pineapples were peeled and cored to obtain pineapple wastes and separated from edible flesh. The pineapple peels and core were washed with tap water before pat dried with tissue. The pineapple peels and core were sliced to small pieces. Peels and core weighing around 100 g were used under each experimental condition.

2.2 Chemical and instruments

The chemicals such as 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and Folin-Ciocalteu reagent were purchased from Merck, while sodium carbonate (Na_2CO_3), ethanol and gallic acid were purchased from Sigma-Aldrich. The drying process was carried out in a domestic microwave oven (2.45 GHz, SAMSUNG, Model M183GN, Thailand) that has power levels ranging from 180 W to 850 W.

2.3 Microwave drying procedure

Different microwave power levels were determined as 180, 450, and 850 W in drying experiments at constant sample loading density. These power levels were chosen based on previous literatures to represent the low, medium, and high power level of the microwave oven. An aluminium tray, containing the sample was placed at the centre of microwave cavity. In all the drying experiments, 100 g of pineapple core and peel were utilised. The samples were consistently spread on the plate inside the microwave cavity during treatment for an even assimilation of microwave radiation. Moisture content were recorded at 60 seconds intervals during drying for determination of drying curves by weighing balance. Pineapple core and peels were dried until 10% of wet basis moisture content left.

2.4 Mathematical equation of the drying curve

The moisture content and drying rate of pineapple core and peel were calculated using Eq. (1) & (2):

$$\text{Moisture Content} = \frac{W_i - W_e}{W} \quad (1)$$

$$\text{Drying Rate} = \frac{M_{t+dt} - M_{te}}{dt} \times 100\% \quad (2)$$

Where;

W_i = Weight sample at any time
W_e = Weight dry matter
M_{t+dt} = Moisture content at t+dt (kg H_2O/kg dry matter)
M_t = Moisture content at t (kg H_2O/kg dry matter)
dt = Time interval (s)

2.5 Extraction procedure

Sample extraction was performed according to the method proposed by Arslan and Özcan (2011) with some modification. Approximately 1 g of peels from the drying at 180 W power level, was weighed and 20 ml of ethanol was added into a universal bottle. The mixture was placed in an ultrasonic bath at 50 °C for 30 minutes. Then, the mixture was filtered, and the supernatant was transferred into a new universal bottle for analysis. The steps were repeated using other samples (Peels: 450W and 850 W; Core: 180 W, 450

W and 850 W).

2.6 *Total phenolic content (TPC)*

The total phenolic compound was determined using the Folin-Ciocalteu method by Alfaro et al., (2014) with some modification. The extract samples (0.5 ml) were mixed with 2.5 ml of Folin-Ciocalteu reagent. Then, 2.5 ml of 7.5% Na_2CO_3 was added to the reaction mixture, which was maintained at room temperature for 30 minutes in the dark. The gallic acid was used as standard. The absorbance was measured at 765 nm using a UV-Vis spectrophotometer, and the results were expressed as mg of gallic acid equivalent (GAE) per gram of dry weight.

2.7 *Antioxidant activity by DPPH assay*

The antioxidant activities of the dried pineapple core and peel using DPPH assay were determined using the method by Yuris (2014) with some modifications. The DPPH solution was prepared by adding 10 mg DDPH into 100 ml of ethanol. Then, for sample analysis, 1 ml of extracts of pineapple core and peel at various conditions were mixed with 1 ml ethanolic DPPH solution and 4 ml of ethanol. The sample was shaken and left in a dark to stand for 30 minutes at room temperature before reading the absorbance at 517 nm. The ethanol was used as the blank. Control was prepared using 4 ml of the ethanol mixed with 1ml of DPPH. The inhibitory percentage of DPPH was calculated according to the following equation where A is absorbance:

$$\% \text{ Inhibition} = \frac{A_{control} - A_{sample}}{A_{control}} \times 100\% \quad (3)$$

3.0 Results and discussion

3.1 *The effects of power level on drying rate*

The moisture content and drying rate curve of the pineapple peels and core at different power level were illustrated in Fig.1 and 2, respectively. Fig. 1 shows the drying curves of pineapple peels and core under various microwave power levels (180 W, 450 W and 850 W). The results show that the moisture content was inversely proportional to the drying time; the moisture content of pineapple peels and core decreased with drying time. This was in accordance with the nature of drying characteristics of various fruits and vegetables (Ekezi et al., 2017). As illustrated in Fig. 1, all the

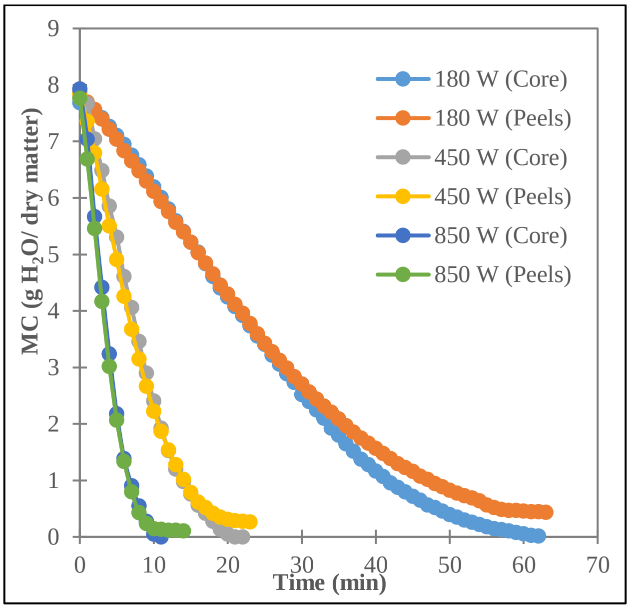

Fig. 1: Moisture content of pineapple core and peels at different power level.

investigated power levels have similar pattern of drying rate. A power level of 850 W provided higher drying rates compared to microwave power at 180 W and 450 W. The removal of moisture from the peels and core using microwave drying at 850 W only required 14 minutes and 11 minutes, respectively. Meanwhile, both peels and core at 180 W and 450 W completed the drying process around 60 minutes and 20 minutes, respectively. At higher power level, more microwave energy is generated, resulting the temperature of pineapple peels and core increased and then enhanced the evaporation rate inside the peels and core. The internal heat from microwave helps increase the internal temperature and vapor pressure, then cause the liquid flow towards the surface, resulting the mass transfer rate of the pineapple peels and core increased rapidly and reduced the drying time as well as improved the quality of product (Seremet et al., 2016). Similar findings were reported by Paengkanya et al. (2015) using vacuum microwave and combined microwave-hot air-drying method. Monteiro et al. (2016) also reported that higher microwave power level resulted in shorter drying times. Fig. 2 shows the good reproducibility of the drying rate curves resulted from all investigated power levels of microwave drying. From the figure, a variation of drying rate with moisture content can be observed for power of 180 W, 450 W and 800 W.

Based on the figure, two periods can be distinguished clearly. The first is called constant rate period and the second is falling rate period. Initially,

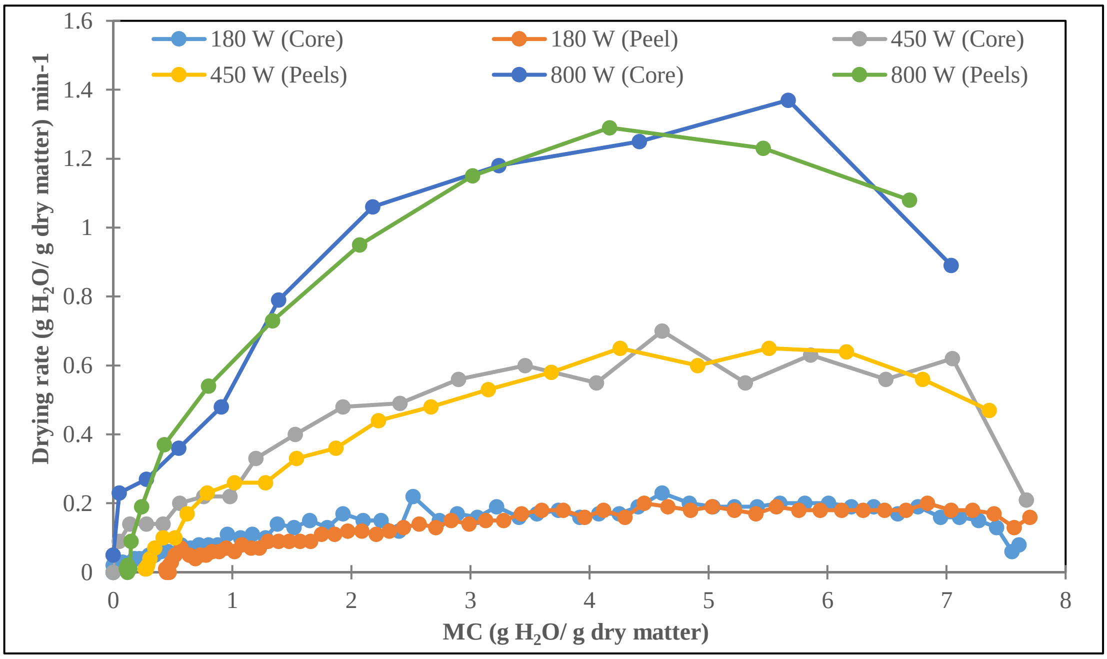

Fig. 2: Drying rate curve of pineapple peels and core at different power.

at higher moisture content, the drying rates of all three power levels for both peels and core were increased. This was due to heating period where conversion of microwave energy into thermal energy took place within the moist material that increases its temperature. Then, the constant rate period was observed for drying at 180 W power level. It can be observed that the drying rate is constant as the moisture content increases. The constant drying period was well-marked for peels and core at 180 W, representing the major amount of water evaporation. Here, microwaves were converted into thermal energy providing the latent heat of vaporisation of free water. According to Lüle and Koyuncu (2015), the rate of moisture removal is mostly dependent on the surrounding conditions and only affected slightly by the nature of the product. Hence, it can be said that the samples are very responsive to microwave application and will absorb the microwave energy quickly and efficiently as long as there is residual moisture.

However, the drying rates for both pineapple peels and core at 450 W and 800 W, show different behaviour than the typical drying rate curves for conventional method. It is not surprising that at higher microwave power levels, no constant rate period occurred. This was probably due to the layer arrangement and too rapid heating by microwaves, providing instantaneous drying (Yunus et al., 2015). The internal heat and mass transfer rates determined the drying rate, thus resulted in rapid drying and no constant rate period. Previous works on microwave and microwave-vacuum drying also stated that the constant rate drying was not observed throughout the drying process of banana (Maskan, 2000), peach (Wang & Sheng, 2006), and mushrooms (Giri & Prasad, 2007). All power levels exhibited the falling rate period for both pineapple peels and core. According to Arslan and Özcan (2011), the falling drying rate period takes place resulting from the predominance of internal diffusion mechanism because of the presence of bound water. Similar finding was reported in previous study by Darvishi et al. (2013). During the initial part of the falling drying rate period, water in larger capillaries is removed first then followed by water in smaller capillaries which resulting in a reduction in the rate of evaporation. Water is highly bound to sites of water-holding components for example protein and starch which is removed at the end of drying process and thus water extraction becomes more difficult, and drying rate decreases as the drying time progresses.

Overall, higher drying rates were obtained with higher microwave power level. It was clearly seen from the figure that drying rates were higher during higher moisture content and decreased with decreasing moisture content. The moisture content of the samples was very high during the initial phase of the drying which resulted in high drying rates due to the higher moisture diffusion. The microwave application for drying therefore offer a distinct advantage, i.e. high drying rate and short drying time (Moghanaki, Khoshandam & Mirhaj, 2013; Lüle & Koyuncu, 2015; Simha et al., 2016).

3.2 Total phenolic compound

The total phenolic content (TPC) in microwave dried pineapple peels and core at different power levels was shown in Fig. 3. TPC is expressed as the gallic acid equivalent (GAE) per gram of dried sample. All dried peels and core exhibited high retention of phenolic content compared to fresh one. The dried peels exhibited the highest retention of total phenolic content (19.8 mg GAE/g dry sample) at 180 W. Meanwhile, dried pineapple core exhibited its highest total phenolic content (21.3 mg GAE/g dry sample) at 850 W. Drying at low microwave power (180 W) created less heat and avoided more degradation of phenolic compounds. However, prolong drying time in microwave will only increase the chance of oxidation of phenolic compounds. Thus, drying at 450 W resulted in the lowest retention of total phenolic content for both peels and core samples.

Inchuen et al. (2010) reported that microwave drying provided higher retention of phenolic compound compared to conventional drying methods. The findings were also supported by Da Silva et al., (2013), that reported on the quality retention of phenolic content during drying process. This behaviour can be explained by liberation of phenolic compound during drying process. Most fruits and vegetables outer layer contain large amount of phenolic compound to protect inner materials. In other words, phenolic compound occurs in plants as the metabolic intermediates and normally accumulate in the vacuoles. It is assumed that more bound phenolic compound is released during food processes due to the breakdown of cellular constituents. Although, the disruption of cell wall may exhibit oxidative and hydrolytic enzyme that could destroyed antioxidant activity, but high power of drying process can deactivate the enzymes and prevent the loss of phenolic compound and thus, resulting to the increase of total phenolic compound.

Izli (2016), stated that the increase in phenolic compound in dried samples may occur because of intense heat from microwave created high vapor pressure and temperature inside the plant tissue causing the disruption of cell wall. In addition, it can be explained that increasing in total phenolic compound because of the degradation of complex phenolic tannins by heat and enzymatic or non-enzymatic oxidation which caused more phenolic to be extracted. Apart from that, these results could be explained by the formation of Maillard reaction product, which caused the new formation of phenolic from precursor during thermal treatment (Sultana et al., 2012). However, some authors (Barroca et al., 2013; Rababah et al., 2015) found that the heat treatment can decrease the phenolic compound during thermal processing. Thus, the effect of drying methods on phenolic compound from different material may not be the same.

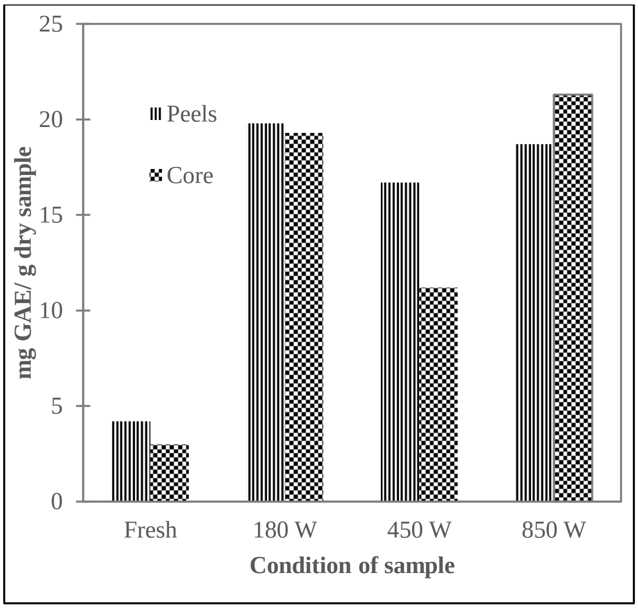

Fig.3: Total phenolic content of peels and core

3.3 Antioxidant activity

The analysis of antioxidant activity was conducted by using DPPH assay. DPPH assay is used to measure the ability of certain extract phytochemicals to scavenge free radicals. It is a useful analysis to understand whether the antioxidant enriched extract can block the oxidation initiation phase by the ability to neutralise or inhibit the formation of radical species. DPPH assay is used because of it is less expensive, rapid and simple assay which do not involve with many steps and reagents. DPPH is useful in examination of antioxidant activity for a quick estimation and preliminary data of radical scavenging capabilities as it is sensitive and requires a little specimen amount. The results of scavenging activity of the sample at different condition were shown in Fig.4. Gradual decrement in the scavenging activity is observed as the power level of microwave is increased. Based on the power level, the scavenging activity reached maximum of 74% for pineapple peels and 53% for pineapple core at 180 W of power level. However, the resulted fresh pineapple peels and core showed vice versa. For pineapple core, the fresh sample reached the maximum scavenging

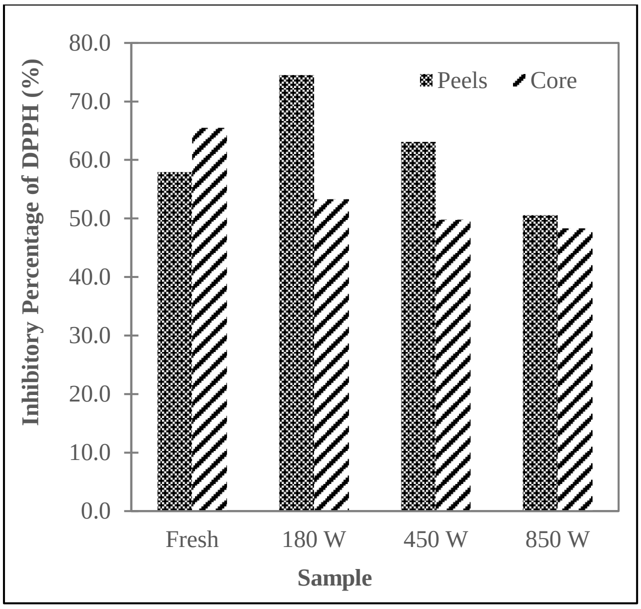

Fig. 4: Inhibition of radical scavenging activity

activity around 65% which was the highest radical inhibition between core samples. Meanwhile, fresh pineapple peels only inhibit 58% radical species which is lower compared to pineapple peels of 180 W. Among the samples, the 180 W of pineapple peels revealed to be a good extraction to scavenge free radical as it given the highest value. Clearly, there were more antioxidant activity present in the pineapple peels in 180 W compared to other samples, which could react rapidly with DPPH radicals and reduced almost DPPH radical molecules corresponding to available hydroxyl groups.

The decrease in the DPPH inhibition of pineapple peels and core treated by microwave drying discussed herein is not a distinctive behaviour reported for other plants. According to Arslan and Özcan (2011), the DPPH free radical scavenging capacity is increased when using high output energy. Inchuen et al., (2010) also reported the similar resulted. They revealed that an improvement in antioxidant activity is achieved when high microwave output power is used as the contact drying time is shorter. Conversely, in this study, high power level presented the lowest antioxidant activity. This occurred maybe due to decrease in product quality. High power input lead to poor quality products due to caramelisation, enzymatic reaction, pigment degradation and ascorbic acid oxidation.

4.0 Conclusions

The drying process was found to have a significant effect on the moisture content of pineapple peels and core. Microwave drying at high power level took shorter time to remove the moisture compared to other power levels. Drying at 850 W reduced 80% of the time required to remove moisture at 180 W. Drying at all power levels retained phenolic compounds and antioxidant activity of dried peels and core. In conclusion, microwave drying can be potentially used as alternative drying method to preserve bioactive compounds as it maintains significant dried product quality.

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