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Effects of Preparation Methods on the Properties of Pineapple Fibers

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Abstract – *The present study reports on the preparation processes and characterization of fibers from pineapple cores. The effects of different washing techniques (tap-water and hot-water washing) and particle sizes (0.2, 0.5 and 1 mm) on two important characteristics of dietary fiber, i.e. water holding capacity (WHC) and oil holding capacity (OHC), were investigated. It was found that the washing pre-treatment significantly improved WHC. Meanwhile larger particle sizes of fiber gave better WHC and OHC for all types of fibers. Tap-water washing was the most appropriate pre-treatment method compared to hot-water washing and unwashed method. However, there was no difference in morphologies of the fibers before and after being prewashed at different particle sizes. The fiber morphology was preserved best after the drying process using microwave freeze dryer (MFD) and microwave vacuum dryer (MVD). This study demonstrates the potential of pre-treatment and drying methods in functional fiber preparation for food enrichment.*

Keywords: Pineapple core, Fiber, Pre-treatment, Washing, Particle size, Drying, Water holding capacity, Oil holding capacity, Morphology

1.0 INTRODUCTION

Pineapple (*Ananas comusus* (L) Merr.) is one of the common crops grown almost in all tropical countries including Malaysia [1]. The by-products from the fruit and green industries are inexpensive and available in large quantities [2, 3]. Parts of pineapple such as its peel, core, crown, bottom and trimmings, which take up about 70% of the whole weight of the pineapple fruit, are considered as by-products. Moreover, 20% of the total by-product in the entire industry was contributed solely from pineapple cores [4].

By-products from food and plants such as pineapples contain relatively high fibre. Pineapple fiber consists of cellulose, lignin and ash, which are about 70-82%, 5-12% and 1.1%, respectively [5]. The high fraction insoluble fibre can be applied in food applications [6]. Dietary fibers of fruits and plants in functional food application may bring advantages by reducing calories, avoiding syneresis and modifying the viscosity of the final product [7]. Several diseases including cardiovascular disease, diverticulitis, constipation, irritable colon, colon cancer and diabetes can be avoided via consumption of these dietary fibers [8].

Technological pre-treatments have been studied previously in order to improve the functional properties of dietary fibers [9]. Various methods of treatment were applied either via chemical and mechanical methods. Treatments such as milling [10], washing conditions [10, 11, 12], particle size [11, 12] chemical treatment and drying [12] have been proven to give significant effects towards fiber characteristics.

To the best of our knowledge, studies on pre-treatment using different washing techniques and particle sizes on a pineapple core fiber are scarce. Thus, the objective in the present study is to examine the pre-treatment effects of washing, particle size and drying methods on the pineapple core fiber characteristics. The present study reports the effect of different washing techniques and particle sizes on two important characteristics of dietary fiber; water holding capacity and oil holding capacity. The morphologies of raw and pre-treated fibers in all particle sizes were analyzed using Fourier Transform Infrared (FT-IR) Spectroscopy. The effect of different drying processes was evaluated using a Scanning Electron Microscope (SEM).

2.0 METHODOLOGY

2.1 Material

Pineapple cores were collected from Lee Pineapple Company Pte. Ltd in Johor, Malaysia. The powdered samples were kept in air-tight containers and stored in a freezer at -20 ºC (ACSON, Malaysia) to maintain freshness and avoid contamination.

2.2 Chemical

Potassium bromide is of analytical grade and purchased from Sigma-Aldrich, USA. Sunflower oil was purchased from a local supermarket.

2.1 Sample Preparation

The pineapple cores were chopped and dried overnight in a hot air oven (Memmert, Germany) at 60 ºC and later grinded using a heavy-duty blender (WARING, USA). Sample powders were sieved through different mesh sizes (0.2, 0.5 and 1 mm) using a Restch sieve shaker (AS 200 basis, Germany). The powdered samples were stored at -20 ºC in an air-tight container before further use.

2.2 Sample Pre-treatment

The pineapple core fibers (0.2, 0.5 and 1 mm) were pre-treated via two types of washing conditions i.e. using hot water and also tap water. Unwashed fiber was the control for this test. A 30 g sample was drenched and soaked with hot water (100±1 ºC) or tap water (27±1 ºC) for 5 minutes. All subsequent analyses were replicated for three times.

2.3 Characterization Analysis

Water Holding Capacity (WHC) and Oil Holding Capacity (OHC) of the dried fiber were determined based on the method by Sangnark and Noomhorm [12] with slight modifications. The sample from Fourier Transform Infrared (FT-IR) analysis was mixed and pulverized with a mortar and pestle, together with potassium bromide and then compressed into tablets. The

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FTIR analysis was carried out using an FTIR Spectrometer (Spectrum 2000 Explorer, Perkin-Elmer, Waltham, MA), with a resolution of 4 cm^{-1} and in the range of 4000–400 cm^{-1}.

2.3 Drying Process

The unwashed fiber was dried using four different drying methods, which are freeze drying (FD), microwave combined with freeze drying (MFD), vacuum drying (VD) and microwave vacuum drying (MVD). 250g samples from each drying technique were weighed and dried until the moisture content (wet basis) of the fiber is reduce to lower than 6%. Moisture Determination Balance (FD-620) was used to determine the moisture content of the fiber. Freeze drying (FD) was carried out at 100 Pa absolute pressure, -40˚C cold trap temperature and heating plate of 60˚C. The sample for MFD was under 100 Pa (absolute pressure), -40 cold trap temperature, 30W (microwave power) and heating plate of 60˚C. The sample that was dried using MVD used 30W of microwave power with 60 Pa absolute pressure whereas the VD process was performed under 60 Pa absolute pressure and temperature of 60ºC. The microstructure was determined by using the Scanning Electron Microscope (Supra Zeiss, Germany).

3.0 RESULTS AND DISCUSSION

3.1 Effect of treatment on Water Holding Capacity and Oil Holding Capacity of fibers

WHC is defined as the water retention capability of a material when exposed to excessive water without any pressure or force except for gravity and environmental force. In Figure 1(a), it clearly shows that washing the pineapple fiber before drying can facilitate the fiber in holding a larger amount of water compared to unwashed fibers (control). This result corroborated with previous studies [9, 10, 11]. Washing pre-treatment contributes to sugar removal that increases the WHC of the fiber [11]. Tap water washing demonstrated a slightly higher WHC than hot water washing, which is similar with other previous findings [9, 10, 11]. Hot water may disrupt the pores on the fiber surface, subsequently increasing the density of fiber and reducing WHC. Oil holding capacity is defined as the ability of a food structure to prevent oil from being released from the structure of the fiber. The chemical and physical structures of plant polysaccharides are highly influential in determining the value of OHC [5]. As illustrated in Figure 1(b), there are slight differences in OHC among the pretreatment techniques.

In Figure 2(a), different washing pretreatment techniques affect the WHC value. The WHC of the fiber is also affected by different particle sizes. Smaller particle size lowers the fibers' capability of holding water and is perhaps due to small particle size having higher fiber density, which reduces the WHC [12]. Small particle size facilitates the loss of soluble dietary fiber components [7]. Figure 2(b) shows that the washing pretreatment technique does not affect the OHC. This is in agreement with previous findings [9, 12]. Furthermore, OHC does not depend on sugar or soluble fiber removal. [13] However, the surface properties, overall charge density, thickener and hydrophobic nature of the fiber particles could affect the characteristics of OHC.

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Journal of Advanced Research Design
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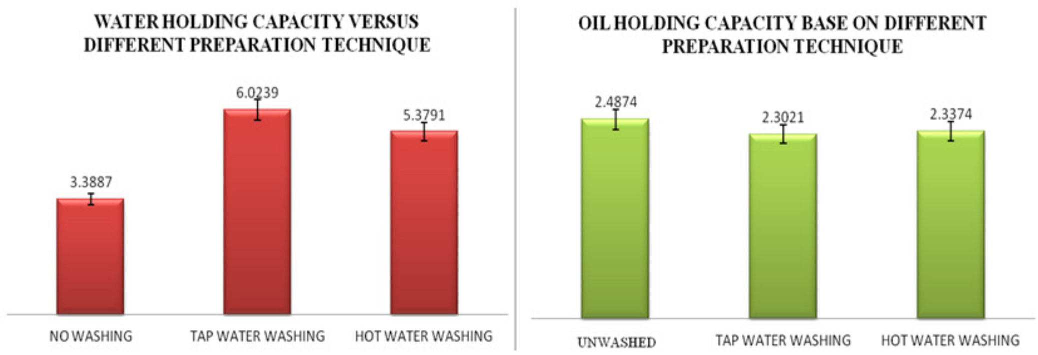
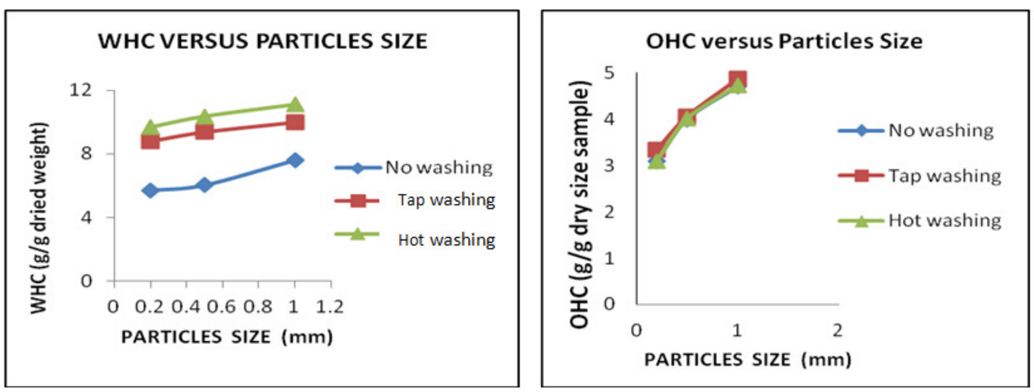


(a) (b)

Figure 1: (a) Water holding capacity (g water/ g dry weight) and (b) Oil holding capacity (g oil/ g dry weight) of different preparation technique



(a) (b)

Figure 2: (a) Water holding capacity and (b) Oil holding capacity (g oil/ g dry weight) of different particles sizes

3.2 Effect of pre-treatment and particle sizes on chemical properties of fibers

Analysis of pineapple core fibers using Fourier transform infrared spectroscopy was performed to determine the functional group of raw pineapple core and treated pineapple core for all particle sizes as shown in Figures 3(a) – (b). There were no differences in peak data of each particle sizes with different pre-treatments. This indicates that the pre-treatment technique does not change the content or composition of the pineapple core fibers. No chemical, physical or biological factors were used in the pre-treatment. The hot water treatment only affected the physical structure but not excessively to disrupt the formation of the functional group or chemical bond. From the data, it is clearly shown that different pre-treatments with different particle sizes only alter the physical structure of the pineapple core fiber but the functional groups and chemical bonds of the fiber remain intact, whereby only

Penerbit Akademia Baru

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the van der Waals intensity of the hydroxyl group and also the hydrogen bonding varies with the different pre-treatments (peak at 3405, 2000, 1250, 1050 cm-1).

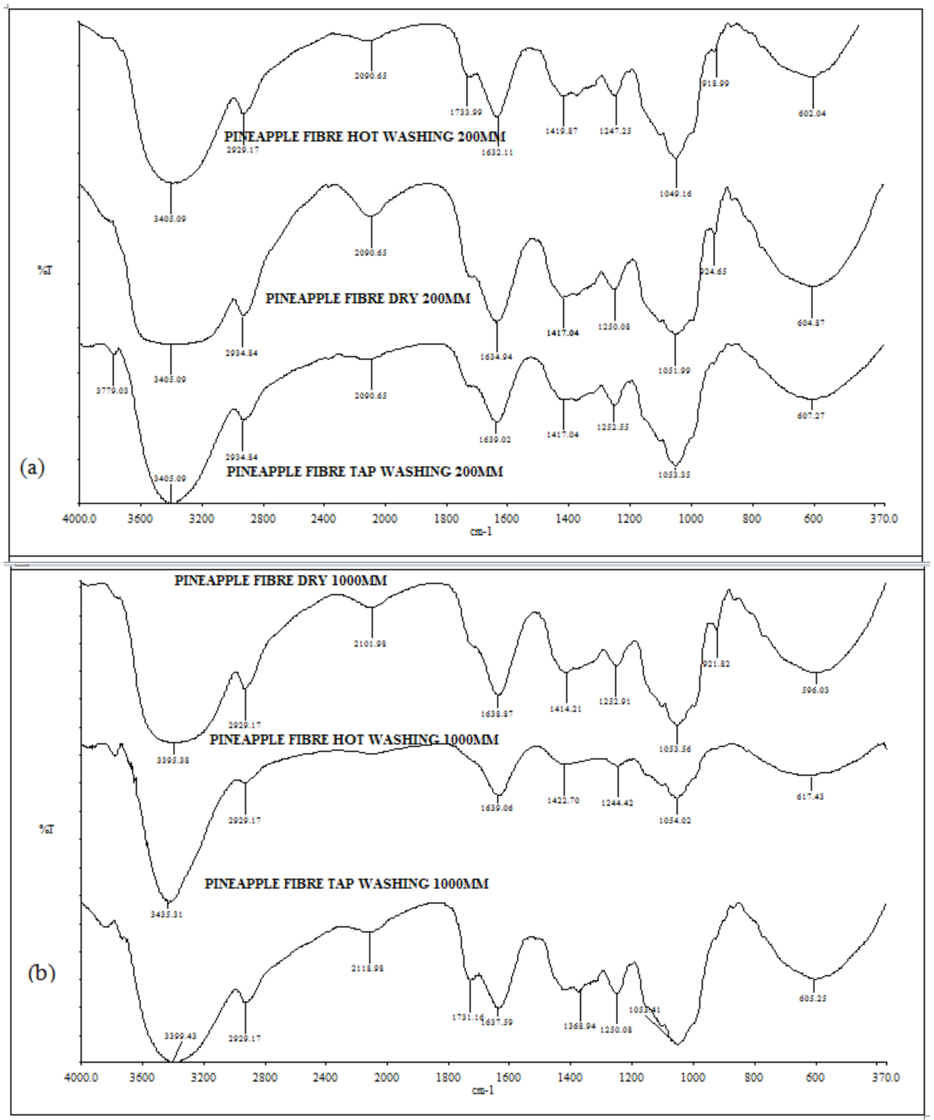

Figure 3: Fourier transform infrared (FT-IR) spectroscopy analysis within the range of 4000 to 370 cm^{-1} for tap, hot water washing and unwashed (control) fiber with particles sizes of a) 200 and b) 1000 micrometres.

3.3 Effect of drying methods on the microstructure of fibers

The microstructures of the pineapple core fiber after different drying processes are illustrated in Figure 4. Honeycomb network of fibers is clearly depicted in the FD sample (4a). However, the application of a microwave in the MFD had slightly affected the size of porous structure of the honeycomb network when combined with FD as shown in Figure 4b. The porous structures expanded, which result in lesser amounts as compared to the FD sample but still sustaining the honeycomb network. Both methods involve a freezing phase, which formed ice crystals on the samples, which then goes through the sublimation stage. This result corroborated with Huang et al. [14]. In addition, collapsed and unclear porous structures were observed in VD (4c) and MVD (4d) fibers. However, the MVD sample demonstrated less severe and less number of unclear porous structures as compared to VD fibers. Similarly, both samples turned into 'conglutination structures' which is caused by direct heating without going through a freezing phase. This situation is supported by the condition of the drying process under internal vacuum and vapour pressure. Direct heat contributes to shrinkage of the fiber cell structure. Huang et al. [14] stated that the effect of steaming and breaking could cause the disfigurement of the original cell structure.

Choosing an appropriate method of drying may enhance the quality of the product and reduce the capital cost of production. FD and VD methods were chosen as common drying methods for food production based on the quality and characteristics of the product. However, FD and VD lead to high energy consumption due to its long duration that contributes to higher capital cost. Thus, the application of microwaves to be incorporated with other techniques has been highly recommended. MFD and MVD provide better rehydration rates, shorten the duration of rehydration and increase water retention [14]. Selecting between MFD and MVD depends on the desirable characteristics of the product and the size of its production. For MFD, little amounts of energy from the microwave are absorbed by the frozen material, which lead to a longer duration for drying as compared to MVD. Thus, MFD has been suggested to be applied in the manufacturing of higher quality dietary fibers with the best appearance whereas the MVD application is more suited for large fiber productions.

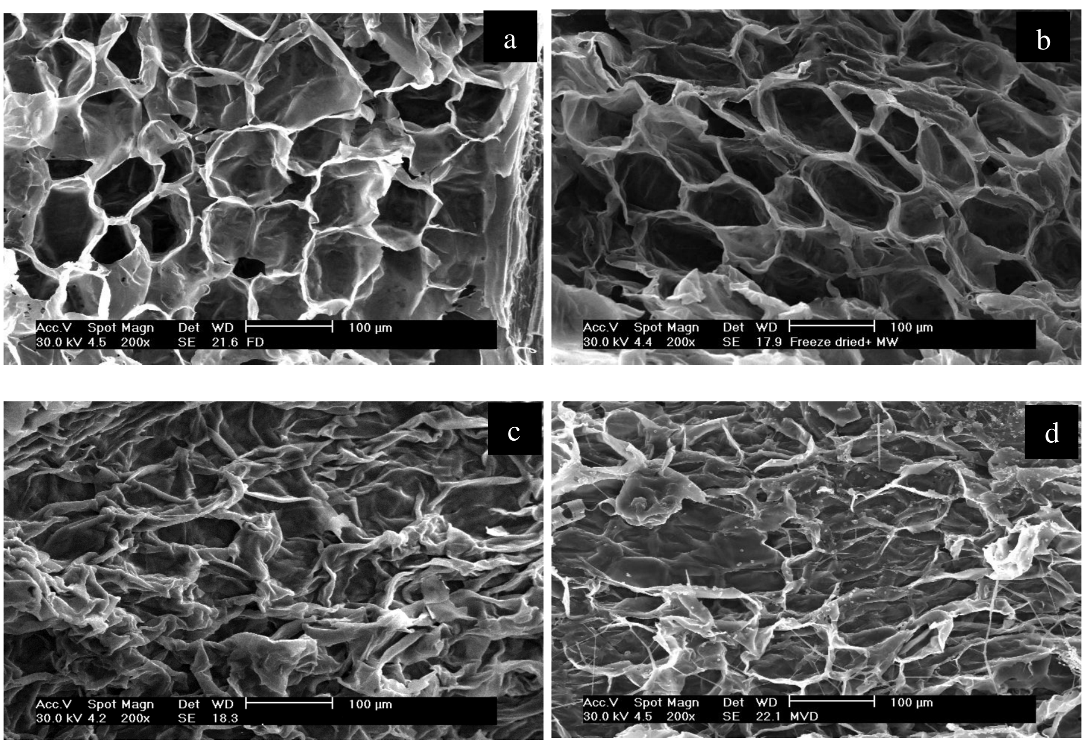

Figure 4: Scanning electron micrographs of pineapple core fibers using different drying methods a) freeze dry, FD; b) microwave combined with freeze dry, MFD; c) vacuum dry, VD; d) microwave vacuum dried, MVD

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4.0 CONCLUSSION

The current work may provide insights for further development of functional fiber preparation, particularly fibers from fruit by-products of food enrichment industries. From this study, a few conclusions could be drawn. Washing pre-treatments and large fiber particle sizes of pineapple cores improve the WHC meanwhile the OHC could be enhanced by the large fiber particle size but is not affected by washing pre-treatments. There was no significant difference in the chemical bonds of fiber after the pre-treatment and application of different particle sizes. The application of microwave (MFD and MVD) has been highly recommended to be incorporated into the drying process.

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Journal of Advanced Research Design
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