CAFEi2016-168

Effect of grinding on physicochemical properties of dietary fibre powder from pink guava by-products

I. Aida Hamimi[1,a], A.S. Norhartini[1], and I. Amin[2]

[1]Food Technology Centre, MARDI, Malaysia; [2]Faculty Medicine and Human Science, University Putra Malaysia.

Abstract

This study was aimed to evaluate the effect of grinding on physicochemical properties of dietary fibre powder (DFP) from pink guava by-products for potential applications in foods. The DFP were divided into three groups of by-product which are refiner waste (RW), siever waste (SW) and decanter waste (DW). The studied samples were analysed for its particle size distribution, bulk density, water-retention capacity, oil-retention capacity, swelling capacity, and particle structures. For particle size distribution, the largest amount of DFP were retained on the 425 µm and 250 µm screen sizes except for RW where 66% of the particle size was more than 600 µm. For bulk density, all large-size particles of DFP showed lower density than small-size ones as smaller particles size would have a higher packing density due to the increase in porosity. The reduction in particle size resulted in increased hydration properties for SW and DW. On the other hand, a decrease in particle size of RW had decreased the ability of hydration properties. A similar trend of oil-retention capacity (ORC) of DFP was evident. ORC was found to increase with smaller particle size for SW and DW and no significant difference ($p>0.05$) for RW. The study of microstructures revealed that the grinding process resulted in the rupture of the hollow physical structure of fibre matrix and in a scale type structure, thereby providing increased surface area for water and oil absorption. As a result, DFP pink guava could be used not only for dietary fibre enrichment, but also as functional ingredients in many food products.

Keywords: dietary fibre, pink guava, by-products, physicochemical properties

INTRODUCTION

Interest in food rich in dietary fibre (DF) has increased in the recent decades, and the importance of this food constituent has led to the development of a large market for fibre-rich products and ingredients (Dhingra et al., 2012). Over the past decade, high DF materials from fruits have been steadily introduced in the world markets. The physiological functions of dietary fiber are likely to depend on its physicochemical properties such as hydration capacities, absorption of organic molecules and its microstructures (Kuan and Liong, 2008). These properties are desired mostly by the food industries, which are often challenged to produce new functional ingredients derived from natural sources. By-products from fruit industry may become cheap raw materials for food and fodder production. From economic perspective, the potential reuse of a by-product as a raw material for production of new products has made it possible to reduce the troublesome seasonal pattern from which some food industries suffer.

Therefore, the objective of the study was to investigate the effect of grinding on physicochemical properties of DFP derived from pink guava by-products.

MATERIALS AND METHODS

Samples of pink guava by-products were collected from Golden Hope Fruit and Beverages Sdn. Bhd., in Manjung, Perak. The three types of pink guava by-products were

[a] E-mail: aida@mardi.my

e-ISBN 978-967-960-401-6

refiner (RW), siever (SW) and decanter (DW). The analysed samples were taken three times throughout the study for replication. These samples were then dried in an oven at 65 ºC for about 8 h then the samples were ground and stored in air-tight containers before analyses.

For physical properties such as particle size distribution, bulk density and microstructures were determined according to the method of Prakongpan et al., (2002). For functional properties such as water holding capacity and oil holding capacity, method described by Ang, (1991) was followed. For swelling capacity, dietary fibre powder (DFP) pink guava by-products was analysed by the bed volume technique after equilibrating in excess solvent (Kuniak and Marchessault, 1972).

Statistic Analysis

Three measurements were taken for each type of analysis. Results were expressed as a mean of the values ± standard deviation of the three separate determinations. Comparison of means was performed by one-way analysis of variance (ANOVA) followed by the LSD test. ANOVA was performed at $p<0.05$ to consider any significant differences. Statistical analyses were carried out using the SAS V. 9.1 software (SAS, USA).

RESULTS AND DISCUSSION

To evaluate the physical properties of DFP; its, particle size distribution, bulk density, water-retention capacity, oil-retention capacity, swelling capacity, and particle structures, were analysed.

Particle size distribution

Table 1.0 shows the percentage of particle size distribution of DFP using different mesh sizes of 600, 425, 250, 140 and 100 µm. The largest amount of DFP pink guava by-products was retained on the 425 µm and 250 µm screen sizes. These results were consistent with Larrauri, (1999) and Sangnark and Noomhorn, (2003), who stated that in general the products with high content of dietary fibre have particle sizes between 150 and 430 µm. Except for RW where 66% of the particle size was more than 600 µm. RW was mainly consists of seed that difficult to crash during grinding. The process of grinding was the major factor affecting particle size of fibres (Raghavengra et al., 2005).

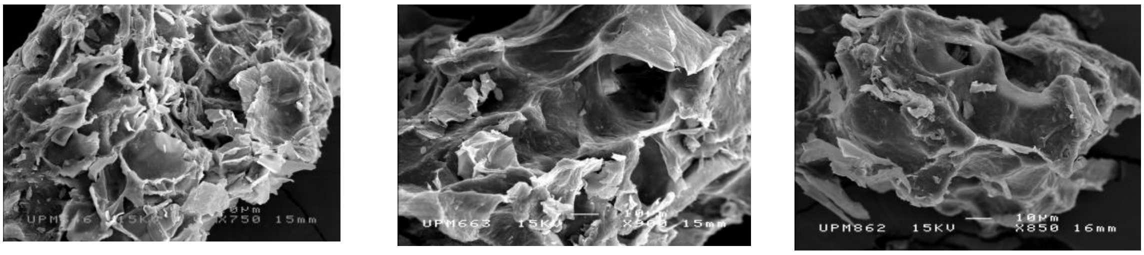
Table 1. Particle size distribution of DFP pink guava by-products

Sieve size (µm)	% Retained on Sieve		
	RW	SW	DW
600	24.8 ±0.96^{a}	27.9 ±0.12^{a}	2.5 ±0.13^{a}
425	7.1 ±0.37^{b}	42.2 ±0.49^{b}	49.8 ±0.78^{b}
250	1.7 ±0.53^{c}	30.4 ±0.35^{c}	47.6 ±1.41^{b}
140	NA	13.4 ±0.13^{d}	8.9 ±0.81^{c}
100	NA	NA	NA

Note: Results are means of triplicate analyses. ^{abc} Means in the same column with different letters indicate significant difference at p<0.05). NA: Not Applicable, RW – Refiner, SW – Siever, DW – Decanter

Scanning Electron Microscopy (SEM)

Figure 1.0 shows the images obtained by electron microscopy scanning of DFP pink guava by-products at x 750 magnification. The scanning electron micrograph showed the collapse of matrix structure and the surface area of the studied samples. The grinding process resulted in the rupture of the hollow physical structure of fibre matrix and in a scale type structure, thereby providing increased surface area for water and oil absorption (Sangnark and Noomhorn, 2003). This opened structure, increased the surface area, trapping more water/oil molecules, therefore exhibited higher water/oil holding capacity (Kuan and Liong, 2008).

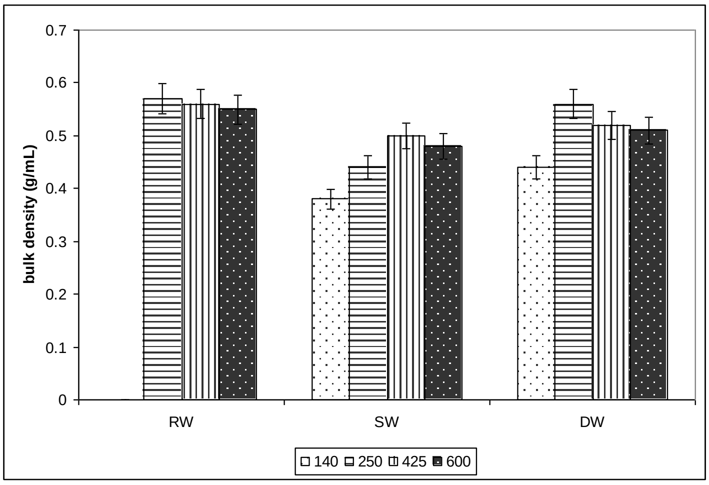


Refiner Siever Decanter

Figure 1. Scanning Electron Micrograph of refiner, siever and decanter. Size mesh 250 µm (B); Bar = 10 microns, magnification at x 750

Bulk density

Bulk density of various sizes (140 to 600 µm) of DFP pink guava by-products are shown in Figure 2.0. For refiner, there was no significant difference in bulk density between the different particle sizes. In siever, particle size 425 µm had higher bulk density than other particle sizes. For decanter, bulk density was higher at 250 µm particle size. Normally, the bulk density of the fibre depends on their shapes and sizes. All large-size particles of DFP showed lower density than small-size ones. According to Robertson et al. (2000), smaller particles size would have a higher packing density due to the increase in porosity.

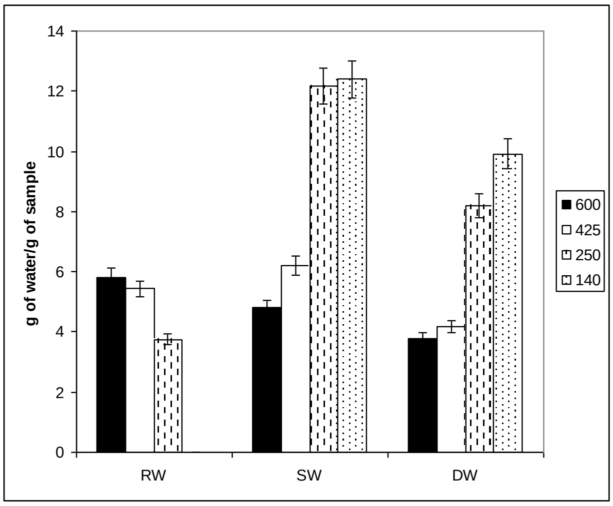


Note: RW- Refiner; SW – Siever; DW – Decanter.

Figure 2. Bulk Density of DFP Pink Guava By-Products

Water-retention capacity (WRC)

As shown in Figure 3.0, WRC of the DFP pink guava by-products ranged between 3.75 to 12.4 g of water/g of fibre. The study also indicated that the decrease in particle size from 600 to 140 µm resulted in an increase in WRC for siever and decanter. Upon grinding, an increase in the theoretical surface area and total pore volume could be the reason in the increase of WRC in SW and DW (Raghavendra et al., 2006). The scale type structure in DFP (Figure 1.0) gave more porous structure to the samples; this has increased the density, and increases its ability to retain water. Statistically, there was a significant difference ($p<0.05$) of water retention ability for different particle sizes among the DFP. On the other hand, a decrease in particle size of RW had decreased the ability of WRC in DFP. This finding was in line with Prakongpan et al. (2002), who reported that, as the particle size of pineapple core dietary fibre and pineapple core cellulose fibre were reduced as a result of mechanical milling, the WRC was also reduced.

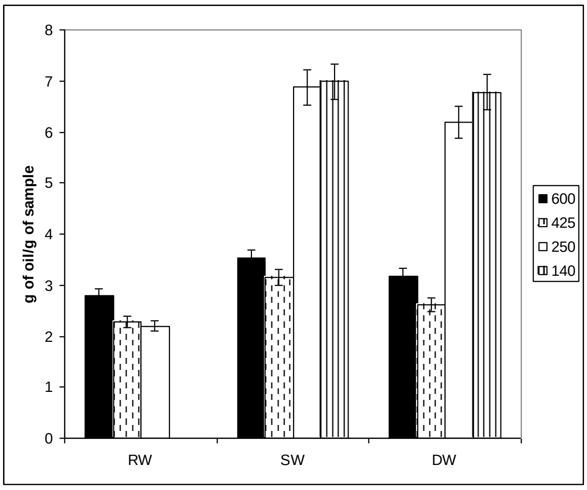


Note: RW- Refiner , SW – Siever, DW – Decanter

Figure 3. Water retention capacity (WRC) of DFP pink guava by-products

Oil- Retention Capacity (ORC)

A similar trend of oil-retention capacity (ORC) of DFP and its water-retention capacity was evident. ORC was found to increase with smaller particle size for SW and DW and no significant difference (p>0.05) for RW (Figure 4.0). According to Femenia et al. (1997), and Prakongpan et al., (2002), ORC was related to the particle size, surface properties, overall charge density and hydrophilic nature of the individual particles, whereby those particles with the greatest surface area posses greater capacity for absorbing and binding component of an oily nature (Kuan and Liong, 2008). The mechanism of ORC was mainly due to the physical entrapment of oil by capillary attraction.



Note: RW – Refiner, SW – Siever, DW – Decanter

Figure 4. Oil retention capacity (ORC) of DFP pink guava by-products

Swelling Capacity

The swelling capacity (SWC) for DFP pink guava by-products ranged from 10.87-15.0 ml water/ g (Table 5.0). As a whole, SWC of DFP pink guava by-products were remarkably higher; this may due to due to shearing of the cell wall and collapse of matrix structure upon grinding due to increase in the surface area and total pore volume. According to Figuerola et al. (2005), the structural characteristic played important roles in the kinetics of water uptake in fibre.

Table 2. Swelling capacity (SWC) of DFP pink guava by-products

Particle Size (µm)	SWC (mL of water/g of fiber DM)		
	RW	SW	DW
600	10.83 ± 3.82[a]	13.33 ± 2.89 [a]	15.00 ± 0.00[a]
425	13.33 ± 1.44[b]	13.33 ± 2.89 [a]	14.17 ± 1.44[b]
250	13.33 ± 1.44[b]	11.67 ± 1.44 [b]	14.17 ± 1.44[b]
140	NA	11.67 ± 1.44 [b]	10.83 ± 1.44[c]
100	NA	NA	NA

Note: Results are means of triplicate analyses. [abc] Means in the same column with different letters indicate significant difference at level $p<0.05$. NA: Not Applicable, RW – Refiner, SW – Siever , DW – Decanter.

CONCLUSIONS

The following conclusions can be drawn from the study:

– Grinding may affect the hydration properties, in particular, the kinetics of water uptake as the result of the increase of surface area, the fibres hydrate more rapidly. The grinding operation resulted in the rupture of the hollow physical structure of fibre matrix and resulted in a scale type structure, thereby providing an increased in surface area for water and fat absorption.

– The hydration properties of the studied samples depended on particle size. Due to good water retention, oil retention and swelling capacities, DFP pink guava could be used not only for dietary fibre enrichment, but also as functional ingredients in many food products.

Literature cited

Ang J.F. (1991). Water retention capacity and viscosity effect of powdered cellulose. J. Food Sc. *56(6),* 1682-1684.

Dhingra, D., Michael, M., Rajput, H., and Patil, R. T. (2012). Dietary fibre in food: A reviews. J. Food Sci. Technol. 49(3), 255-266.

Kuan, Y. H., and Liong, M. T. (2008). Chemical and physicochemical characterization of agrowaste fibrous materials and residues. J. Agric. Food Chem. 56(19), 9252-9257.

Kuniak, L., and Marchessault, R. H. (1972). Study of the crosslinking reaction between epichlorohydrin and starch.Starch/starke, *24(4),* 110-116.

Larrauri, J. A. (1999). New approaches in the preparation of high dietary fibre powders from fruit by-products. Trends Food Sci. Tech. *10(1),* 3-8.

Prakongpan, T., Nitithamyong, A., and Luangpituksa, P. (2002). Extraction and application of dietary fiber and cellulose from pineapple cores. J. Food Sc. *67(4),* 1308-1313.

Raghavendra, S. N., Swamy, S. R., Rastogi, N. K., Raghavarao, K. S. M. S., Kumar, S., and Tharanathan, R. N. (2006). Grinding characteristics and hydration properties of coconut residue: A source of dietary fiber. J. Food Eng. 72*(3),* 281-286.

Sangnark, A., & Noomhorm, A. (2003). Effect of particle sizes on functional properties of dietary fibre prepared from sugarcane bagasse. Food Chem. *80(2),* 221-229.

Robertson, J. A., de Monredon, F. D., Dysseler, P., Guillon, F., Amado, R., and Thibault, J. F. (2000). Hydration properties of dietary fibre and resistant starch: a European collaborative study. *LWT*-Food Sc. Technol. *33(2),* 72-79.

Femenia, A., Lefebvre, A. C., Thebaudin, J. Y., Robertson, J. A., and Bourgeois, C. M. (1997). Physical and sensory properties of model foods supplemented with cauliflower fiber. J. Food Sc. *62(4),* 635-639.

Figuerola, F., Hurtado, M. L., Estévez, A. M., Chiffelle, I., & Asenjo, F. (2005). Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment. Food Chem*. 91(3),* 395-401.